CMR UNIVERSITY

Private University Established in Karnataka State by Act No. 45 of 2013

PROJECT REPORT

ON

SMART ATTENDANCE SYSTEM USING FACE RECOGNITION

Submitted in partial fulfilment of the requirements

4th Semester

MASTER OF COMPUTER APPLICATION

for the Academic Year 2024-2025

DEVELOPED BY

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2024-2025

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Certificate

This is to certify that Ms. ***SIMRA KHAN*** *bearing the Register Number* ***23DMMCA073*** *belonging to* ***IV Semester, MCA*** *course has satisfactorily completed the project title* ***SMART ATTENTDANCE SYSTEM USING FACE RECOGNITION*** *in partial fulfilment of* ***8CAPS7010: Capstone project*** *prescribed by the University during the Academic Year* ***2024-2025****.*

Prof. Aurangjeb Khan
Project Guide

Dr Ashok Kumar T A
Director, SSCS

Name: Simra Khan

Regno: 23DMMCA073

Date of viva Examination:

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School of Science and Computer Studies

#5, Bhuvanagiri, OMBR Layout, Bangalore- 560 043, Karnataka – India

Declaration

The project titled **Smart Attendance System Using Face Recognition** developed by me in the partial fulfilment of **IV Semester, MCA** programme, is an authentic work carried out by me under the guidance of **Prof. Aurangjeb Khan,** Assistant Professor School of Science and Computer Studies, CMR University, Bangalore.

I declare that the project has not been submitted to any degree or diploma to the above said university or any other university.

Signature: ……

Name: Simra Khan

Reg No: 23DMMCA073

I certify that all the above statements given by the candidate is true to the best of my knowledge and belief.

Signature: ……

Prof. Aurangjeb Khan

Project Guide

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ACKNOWLEDGEMENT

The satisfaction that accompanies the successful completion of any task would be incomplete without the mention of people whose ceaseless cooperation made it possible, whose constant guidance and encouragement crown all efforts with success

We are thankful to the management of **CMR University** for providing such a vigorous environment, assistance and support for the fortunate completion of the project.

We would take immense pleasure to express our sincere gratitude and thanks to our Director **Dr. Ashok Kumar T A**, for his encouragement and constant support for providing us with

the resources to complete our project successfully.

We wish to express our heartfelt gratitude to **Dr. Samratvivekanand Khanna**, Head of Department, School of Science and Computer Studies, for his encouragement and constant support.

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We wish to express our heartfelt thanks to **Prof. Aurangjeb Khan**, Assistant professor, School of Science and Computer Studies, for his encouragement and constant support.

Our special thanks to our parents and friends who have been a great support in the fortunate completion of this project.

Name: Simra Khan

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TABLE OF CONTENTS

1.INTRODUCTION

Attendance management plays a crucial role in both educational institutions and organizations. Traditional methods of recording attendance such as roll calls, manual registers, or even swipe cards are often time-consuming, prone to human error, and susceptible to proxy attendance. In large classrooms or workplaces, taking attendance manually can consume a significant portion of valuable time, reducing productivity and efficiency.

With the advent of Artificial Intelligence (AI) and Computer Vision, face recognition has emerged as a reliable and efficient solution for automating attendance systems. A face is a unique biometric identifier that cannot be easily forged or transferred, making it a secure and accurate method of verifying presence. Unlike fingerprint or RFID-based systems, face recognition is non-intrusive, contactless, and user-friendly, requiring no active participation from the user other than being visible to a camera.

This project, titled "Smart Attendance System Using Face Recognition", aims to automate the process of recording attendance by leveraging Python, OpenCV, and machine learning techniques. The system captures facial images of students or employees, trains a recognition model, and later identifies individuals in real-time during classes or office sessions. Attendance is marked automatically and stored in structured CSV files. In addition, the system provides functionalities to:

- Maintain a centralized list of registered students.
- Automatically generate absentee lists for each session.
- Save unknown face samples for security review.
- Produce analytics and reports in the form of interactive charts, Excel sheets, and PDF summaries.
- Provide a dashboard interface to simplify usage for staff.

The system has been designed in modular form to ensure scalability and flexibility:

- Capture Module – for registering students' facial data.
- Training Module – for preparing the recognition model.
- Recognition Module – for marking attendance in real-time.
- Absentee Module – for identifying absent students.
- Analytics Module – for generating reports and insights.
- Dashboard Module – for providing a user-friendly interface.

By integrating these modules, the proposed system provides a complete end-to-end solution for attendance management. It not only improves accuracy and efficiency but also empowers institutions with meaningful insights into attendance trends, thereby contributing to better monitoring and decision-making.

1.1 OBJECTIVE

The main objective of this project is to design and implement a Smart Attendance System that automates the process of marking attendance using face recognition technology. The system aims to replace traditional manual or card-based attendance methods with a secure, accurate, and contactless solution.

Specific Objectives

1. Automated Face Capture and Registration
    - Develop a module that captures facial images of students or employees through a webcam.
    - Store these images in a structured dataset directory.
    - Maintain a centralized record of all registered individuals in all_students.csv.
2. Face Detection and Model Training
    - Implement Haar Cascade Classifier to detect human faces from images.
    - Train the LBPH (Local Binary Patterns Histogram) face recognizer on the dataset.
    - Save trained models (trainer.yml) and label mappings (labels.pickle) for future recognition tasks.
3. Real-Time Face Recognition and Attendance Marking
    - Enable real-time recognition of faces through a webcam.
    - Accurately identify individuals and mark them as Present in attendance files.
    - Handle unknown or unregistered faces by saving their snapshots separately for review.
4. Absentee Identification
    - Compare the list of registered students with those marked present.
    - Automatically mark remaining individuals as Absent with timestamps.
    - Update daily attendance files in a structured format for easy tracking.
5. Data Storage and Management
    - Store attendance records in CSV format, organized by date.
    - Ensure easy retrieval and modification of records.
    - Maintain consistency and integrity of data across modules.
6. Attendance Analytics and Reporting
    - Generate overall, weekly, and monthly attendance summaries.
    - Provide interactive visualizations using Plotly for better insights.

- Export results into Excel (.xlsx) and PDF reports for academic/organizational use.

7. User Authentication and Security
    - Ensure only authorized staff can run recognition and attendance modules through a login system (staff.csv).
    - Protect attendance data from unauthorized access or modification.
8. User-Friendly Dashboard
    - Design a graphical interface with Tkinter for non-technical users.
    - Provide buttons for capturing faces, training the model, recognizing faces, marking absentees, generating analytics, and exiting the system.
    - Make the system intuitive and easy to operate.
9. Efficiency and Accuracy
    - Minimize time spent on attendance-taking compared to manual methods.
    - Improve recognition accuracy under varying lighting and environmental conditions.
    - Reduce chances of proxy attendance or false entries.

1.2 PROBLEM DESCRIPTION

Attendance management is a vital component in educational institutions and organizations, directly impacting academic performance, discipline, payroll management, and overall productivity. Despite its importance, most institutions still rely on traditional methods such as manual roll calls, paper registers, or RFID cards, which have significant limitations.

- Manual systems are time-consuming, inefficient, and prone to human errors. In large classrooms or workplaces, taking attendance can waste several minutes of valuable time per session.
- Proxy or fake attendance is a major concern, where students or employees can mark attendance on behalf of others, reducing the reliability of records.
- RFID card or biometric systems (fingerprints, punch cards) improve accuracy but are still vulnerable to misuse (e.g., card sharing) and present hygiene concerns due to physical contact.
- These systems lack centralized digital records, making it difficult to analyze trends, track absentees, or generate reports over time.

In the digital era, where automation and security are highly valued, there is a strong need for an automated, accurate, and contactless attendance system. Face recognition provides a viable solution since a person's face is a unique biometric trait that can be captured without physical contact.

2. SYSTEM ANALYSIS

System analysis is the process of examining the existing attendance management methods, identifying their limitations, and designing a better system to address these shortcomings. In educational institutions and organizations, traditional methods such as manual roll calls, paper registers, and RFID card systems are widely used. However, these methods are time-consuming, error-prone, and vulnerable to misuse, such as proxy or buddy attendance. Moreover, they lack centralized data storage and analytics, making it difficult to monitor attendance trends over time. To overcome these limitations, a smart, automated, and contactless solution is required.

2.1 Proposed System

The proposed system is a Smart Attendance System using Face Recognition that automates the process of marking attendance with minimal human intervention. It is designed to capture facial images of students or employees during registration and store them in a dataset. Using Haar Cascade classifiers, the system detects faces, while the Local Binary Patterns Histogram (LBPH) recognizer is trained to identify individuals accurately. When the system is run, it recognizes faces in real time through a webcam and automatically marks recognized individuals as present in the attendance file. Unrecognized or unauthorized faces are saved separately for later verification.

The system further compares the attendance records with the list of registered individuals to identify absentees automatically. All attendance data is stored in structured CSV files, making it easy to retrieve and manage. The system also generates weekly, monthly, and overall reports, along with visual analytics using interactive charts. A user-friendly dashboard built with Tkinter provides staff with buttons for key functions such as capturing faces, training the model, recognizing faces, marking absentees, generating reports, and exiting the system. To ensure data security, only authorized staff members can log in and operate the software. Overall, the proposed system is designed to be efficient, accurate, and scalable, making it suitable for classrooms, offices, and organizations.

2.2 Feasibility Study

To determine the practicality of the proposed system, a feasibility study was conducted under three major aspects: technical, operational, and economic feasibility.

From a technical perspective, the system is highly feasible. It is developed using Python, an open-source programming language, along with libraries such as OpenCV, Tkinter, NumPy, CSV, and Plotly, all of which are freely available. The hardware requirements are minimal, as the system can run on a standard laptop or desktop with at least 4 GB RAM and a basic webcam. Since the system does not depend on costly biometric devices or specialized infrastructure, it can be deployed easily with existing resources. The use of Haar Cascade and LBPH algorithms ensures reliable face detection and recognition under different environmental conditions, making the system technically sound and scalable.

In terms of operational feasibility, the system is designed to be user-friendly and practical for real-world use. The Tkinter-based dashboard ensures that staff without technical expertise can operate the system effortlessly. Attendance is captured automatically in real time, which saves time, reduces manual workload, and prevents errors. The system also addresses hygiene

concerns by providing a contactless method of attendance, making it especially relevant in post-pandemic environments. Security is enhanced by staff authentication and by saving unknown faces for review, thereby ensuring reliable operations.

From an economic standpoint, the system is cost-effective because it relies on open-source tools and readily available hardware. Unlike fingerprint or iris scanners, it does not require expensive biometric equipment, significantly reducing costs. Maintenance expenses are minimal since updates are limited to retraining the dataset when new users are added. By automating attendance, the system also saves administrative time and resources, leading to long-term cost savings. Furthermore, the ability to generate automated reports and analytics adds value that traditional systems cannot provide.

In conclusion, the feasibility study demonstrates that the Smart Attendance System using Face Recognition is technically achievable, operationally practical, and economically viable. It offers a modern and efficient alternative to outdated attendance methods, ensuring accuracy, security, and efficiency.

2.2.3 Economic Feasibility

 Low Development Cost:

- The system uses only free and open-source libraries.
- No need for expensive biometric hardware or commercial licenses.

 Low Maintenance Cost:

- Runs on standard laptops and webcams already available in most institutions.
- Updates are limited to retraining when new users are added.

 Cost Savings:

- Saves staff time previously spent on manual attendance.
- Reduces paper usage and administrative overhead.

 High Value**:**

- Provides additional features like analytics and reporting that traditional systems lack.
- Offers scalability without significant additional cost.

3. REQUIREMENT SPECIFICATION

To develop and deploy the Smart Attendance System effectively, certain hardware and software requirements must be fulfilled. These requirements ensure that the system runs smoothly, processes images efficiently, and provides accurate results.

3.1 Hardware Requirements

- **Processor:** Intel Core i3 or above (i5/i7 recommended for faster processing)
- **RAM:** Minimum 4 GB (8 GB recommended)
- **Hard Disk/SSD:** Minimum 250 GB storage
- **Webcam:** HD (720p) or higher resolution for clear image capture
- **Display:** 14" monitor or above with 1024×768 resolution or higher
- **Optional:** External storage/backup device for attendance records

3.2 Software Requirements

- **Operating System**
  - Windows 10 or later, Linux (e.g., Ubuntu), or macOS.
  - The system is designed to be cross-platform so it can run on commonly used operating systems without compatibility issues.
- **Programming Language: Python 3.x**
  - Python is an open-source, high-level programming language widely used for machine learning, image processing, and data analysis.
  - Its simplicity and extensive library support make it ideal for rapid development of this project.
- **Libraries/Frameworks**
  - OpenCV (Open Source Computer Vision Library) → Provides tools for face detection, recognition, and image processing. It is the backbone of the system's computer vision tasks.
  - NumPy → A fundamental Python library for numerical operations. It supports fast matrix operations, which are essential for image data manipulation.
  - Tkinter → A built-in Python library for creating GUI applications. It is used here to design the attendance dashboard, input dialogs, and message boxes.
  - CSV Module → Used for reading and writing attendance records in .csv format, ensuring compatibility with spreadsheet software.
  - Pickle → Helps save and load Python objects, such as the trained face recognition model and label mappings, for reuse without retraining.

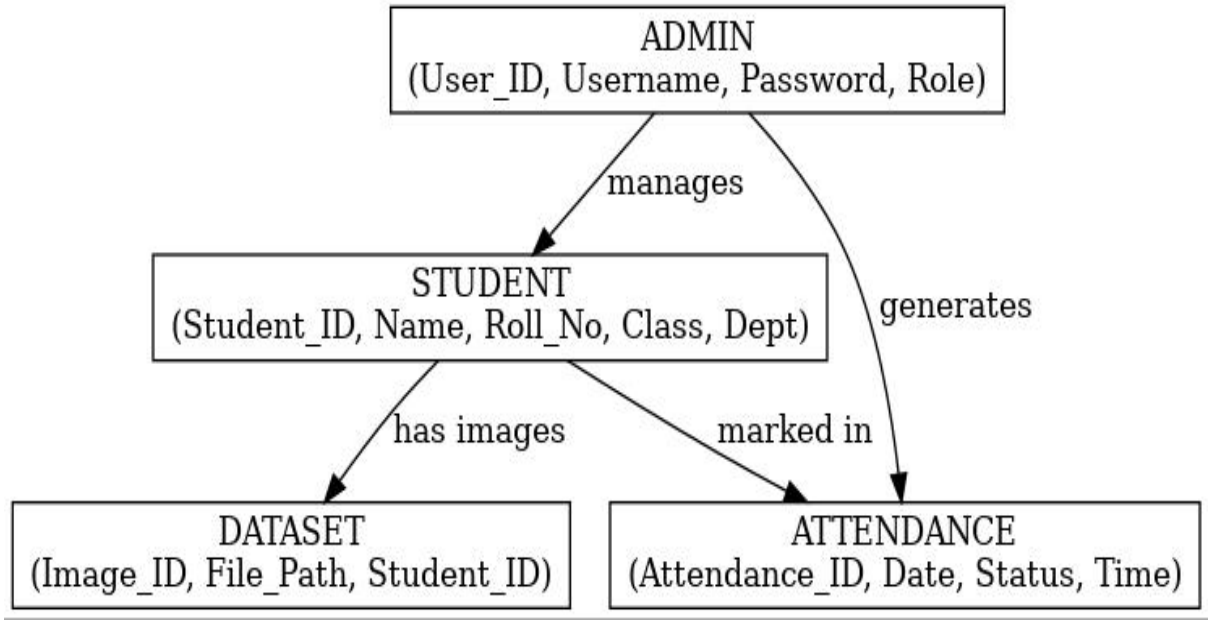
- Plotly → A library for creating interactive and visually appealing graphs. In this system, it is used to display attendance analytics (weekly, monthly, overall).
- OpenPyXL → Provides functionality to create and manage Excel files (.xlsx). It is used to export attendance reports in a structured spreadsheet format.
- ReportLab → A powerful library for creating PDF files. It is used to generate professional attendance reports that can be shared and archived.

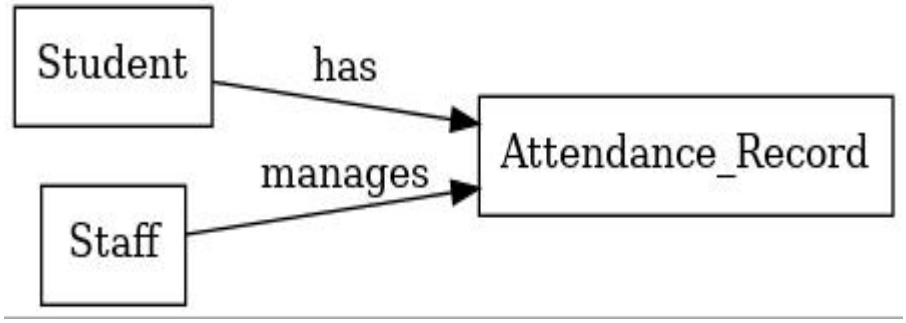
- **Tools**
  - pip (Python Package Installer) → A command-line tool used to install Python libraries required for the project.
  - IDE/Text Editor (VS Code, PyCharm, or IDLE) → Used for writing, debugging, and running the Python scripts.

4. SYSTEM DESIGN

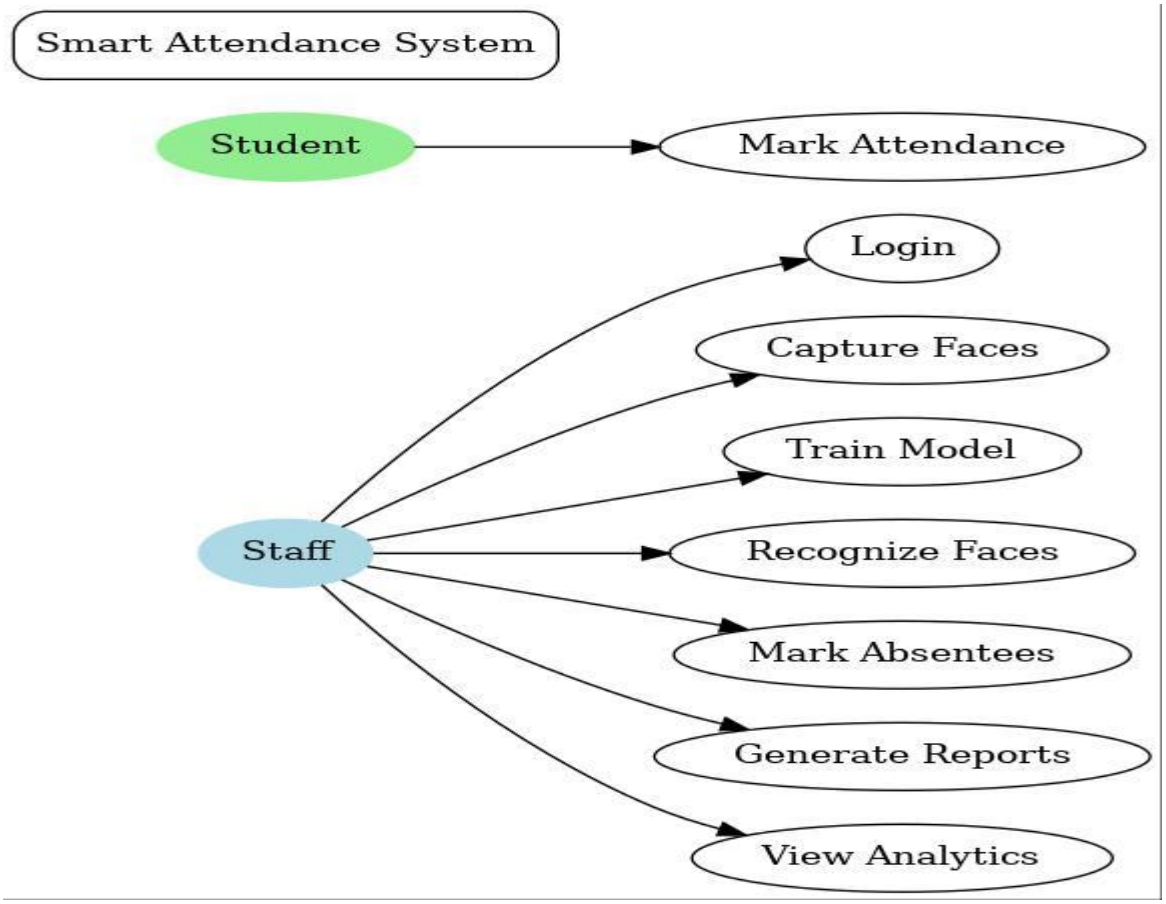
System design represents the blueprint of the system, describing how different components interact to achieve the overall functionality. It involves modelling the structure, behavior, and flow of the system using diagrams.

4.1 ER Diagram (Entity–Relationship Diagram)

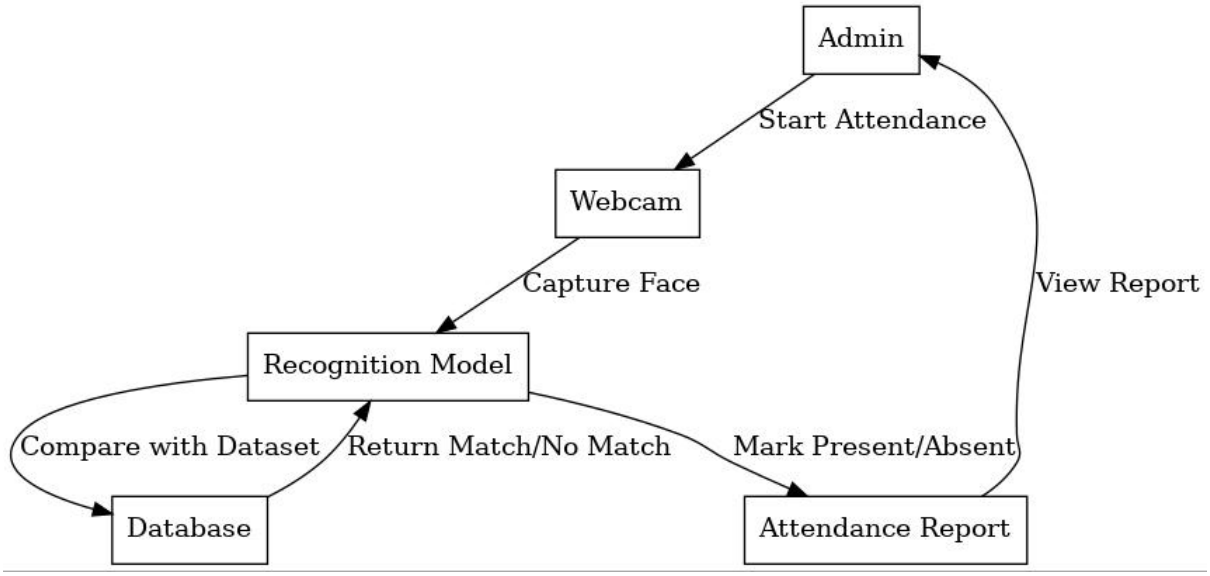




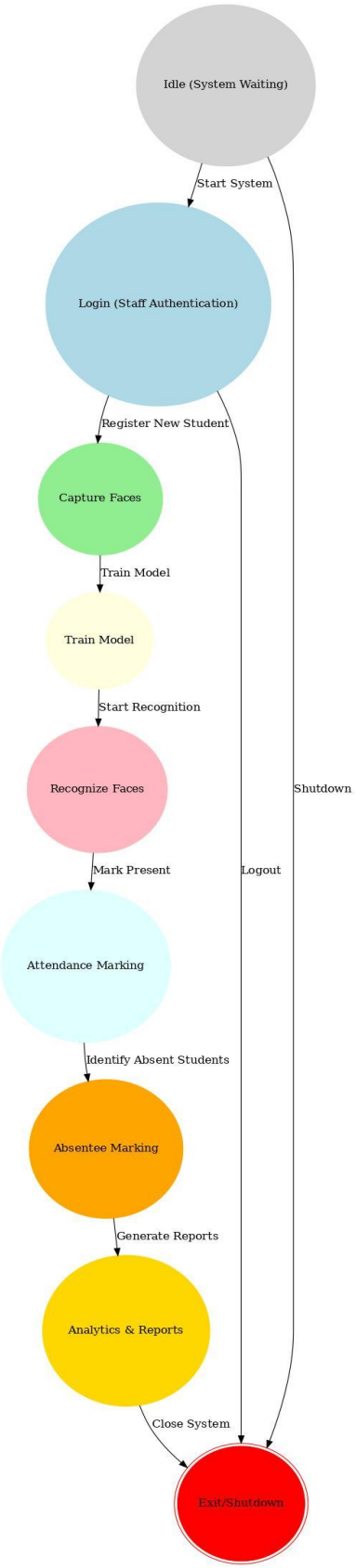
4.2 USE CASE DIAGRAM



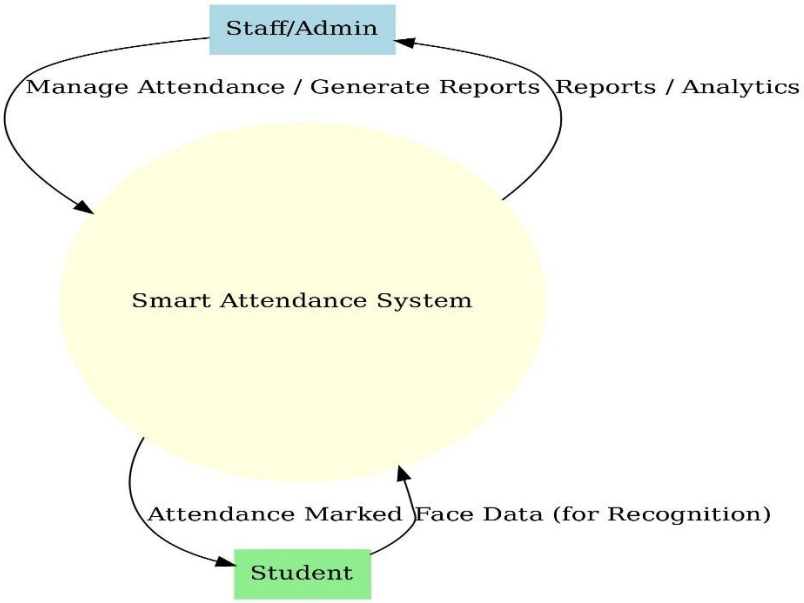
4.3 SEQUENCE DIAGRAM

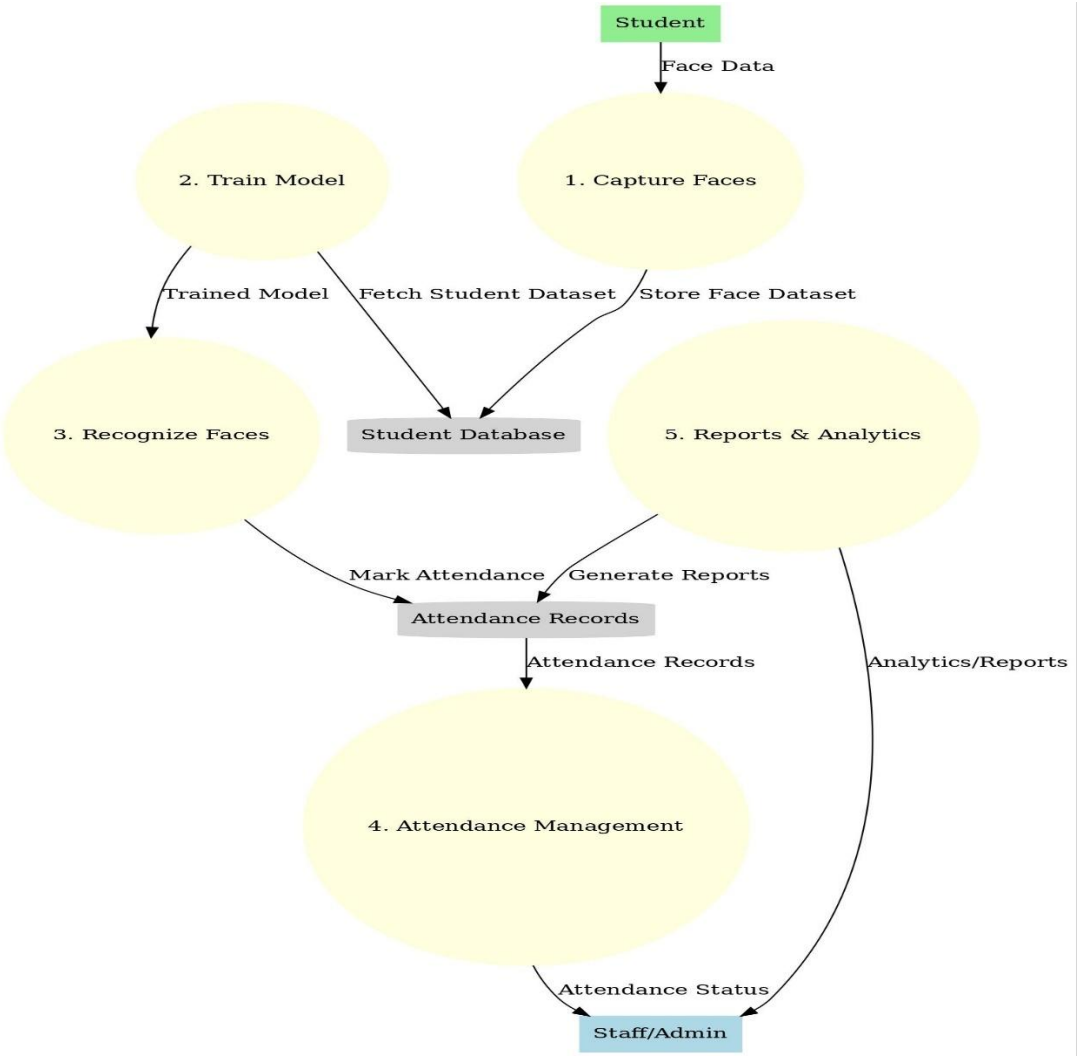


4.4 STATE TRANSITION DIAGRAM



4.5 DFD (Dataflow Diagram)





5. IMPLEMENTATION

5.1 Module Description

5.1.1. Capture Module (capture.py)

- **Objective:**
  To capture face images of students and store them in a structured dataset for training the recognition model.
- **Input:**
  - Student name (entered via Tkinter input dialog).
  - Live video feed from webcam.
- **Process:**
  - Prompt the staff to enter the student's name.
  - Create a dedicated folder for the student inside the dataset/ directory.
  - Start webcam feed using OpenCV (cv2.VideoCapture).
  - Allow the user to press 's' to save an image and 'q' to quit.
  - Save up to 30 images per student to ensure diversity (different angles and lighting conditions).
  - Update all_students.csv file with the new student's name if not already listed.
- **Output:**
  - Folder inside dataset/ containing labeled face images.
  - Updated all_students.csv file with student details.
- **Key Features:**
  - Ensures sufficient training data per student.
  - Prevents duplication of student names.
  - Real-time video feedback during capture.

5.1.2. Training Module (train.py)

- **Objective:**
  To process captured images and train the face recognition model.
- **Input:**
  - Images stored inside dataset/ folder.
  - Haar Cascade Classifier for face detection.
- **Process:**
  - Traverse all student folders inside dataset/.

- Convert images to grayscale for feature extraction.
- Detect faces using Haar Cascade (haarcascade_frontalface_default.xml).
- Extract Region of Interest (ROI) for each detected face.
- Resize images to a fixed size (200x200) for uniformity.
- Map student names to numerical IDs.
- Train the LBPH (Local Binary Pattern Histogram) recognizer using processed data.
- Save the trained model and label mappings.

- **Output:**
  - trainer.yml → Trained face recognition model.
  - labels.pickle → Mapping of student names to IDs.
- **Key Features:**
  - Handles corrupted/unreadable images gracefully.
  - Provides console logs for training progress.
  - Produces reusable training artifacts.

5.1.3. Recognition Module (recognize.py)

- **Objective:**
  To recognize faces in real-time, mark attendance, and store unknown faces for review.
- **Input:**
  - Live webcam feed.
  - Trained model (trainer.yml) and labels (labels.pickle).
  - all_students.csv (master student list).
- **Process:**
  - Perform staff authentication using credentials stored in staff.csv.
  - Load trained LBPH model and student label mappings.
  - Start webcam feed and convert frames to grayscale.
  - Detect faces in each frame using Haar Cascade.
  - Predict student identity using the LBPH recognizer.
  - If confidence ≤ 70%, mark student as present.
  - If confidence > 70%, classify as “Unknown” and save cropped face image into unknown_faces/.

- Update daily attendance file (attendance/YYYY-MM-DD.csv) with status.

- **Output:**
  - Attendance file for the day with present/absent students.
  - Saved unknown face images for security review.
- **Key Features:**
  - Security layer: staff login before recognition.
  - Reduces duplicate unknown entries using image similarity check.
  - Real-time recognition with bounding box and student name displayed.

5.1.4. Absentees Module (absentees.py)

- **Objective:**
  To identify and mark students who are absent for the day.
- **Input:**
  - Daily attendance file (attendance/YYYY-MM-DD.csv).
  - Master student list (all_students.csv).
- **Process:**
  - Load all registered student names from the master list.
  - Read the daily attendance file.
  - Compare present students with the master list.
  - For every student not marked present, add an entry as Absent.
  - Append timestamp for absentees.
- **Output:**
  - Updated attendance file with both Present and Absent students clearly listed.
- **Key Features:**
  - Prevents incomplete attendance records.
  - Automates absentee marking without manual work.
  - Maintains consistency in reporting.

5.1.5. Analytics Module (analytics.py)

- **Objective:**
  To analyze attendance data and generate reports.
- **Input:**
  - Attendance files (attendance/*.csv).

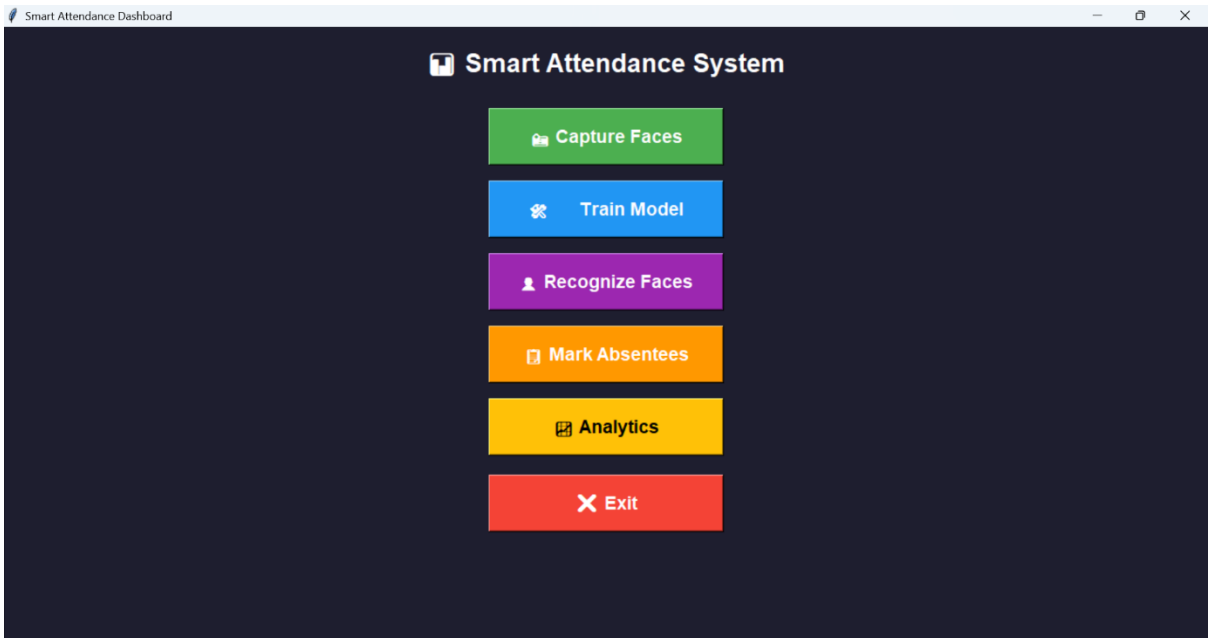
- Master student list.

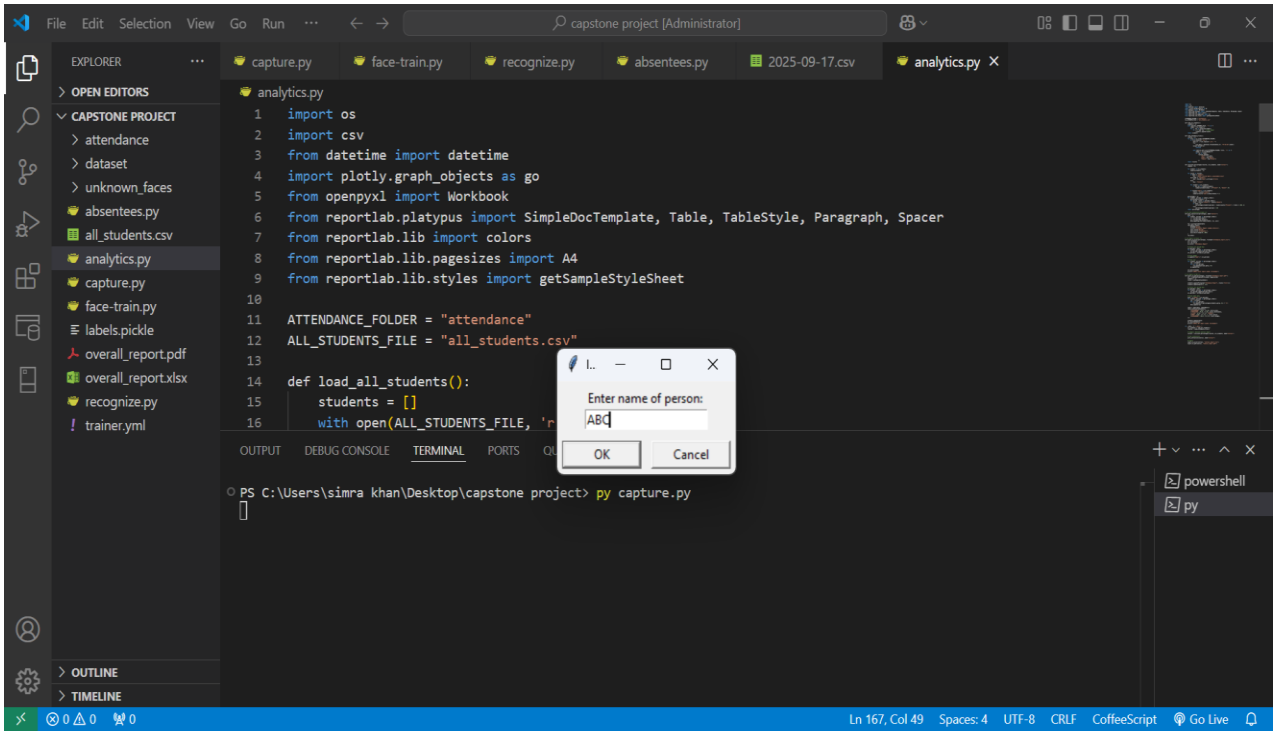
- **Process:**
  - Load attendance records across multiple dates.
  - Group attendance by overall, weekly, and monthly periods.
  - Calculate percentages: (Total Presents / Total Classes) × 100.
  - Generate bar charts for comparison using Plotly.
  - Export reports in Excel (.xlsx) and PDF (.pdf) formats for record keeping.
- **Output:**
  - Visual attendance reports (interactive bar graphs).
  - Exported attendance reports in Excel and PDF.
- **Key Features:**
  - Multi-level analysis (daily, weekly, monthly, overall).
  - Cross-platform compatibility of exported reports.
  - Professional report formatting using ReportLab and OpenPyXL.

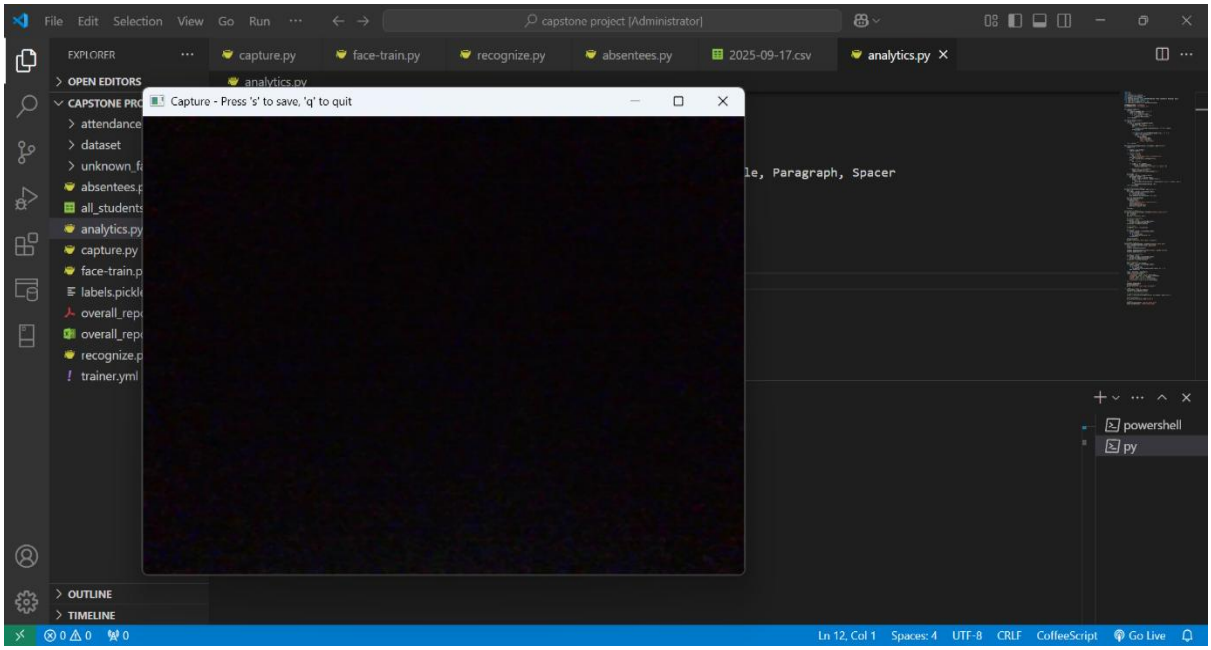
5.1.6. Dashboard Module (dashboard.py)

- **Objective:**
  To provide a graphical interface for easy system operation.
- **Input:**
  - User interaction via button clicks.
- **Process:**
  - Create a GUI window using Tkinter.
  - Display system title and color-coded functional buttons.
  - Map each button to corresponding Python module using os.system().
  - Allow staff to exit the system safely with confirmation dialog.
- **Output:**
  - Dashboard window that launches Capture, Train, Recognition, Absentees, and Analytics modules.
- **Key Features:**
  - Intuitive, user-friendly design.
  - Eliminates need for command-line usage.
  - Single control point for entire attendance system.

5.2 SCREENSHOTS



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capstone project [Administrator]
EXPLORER
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face-train.py
recognize.py
absentees.py
2025-09-17.csv
analytics.py
OPEN EDITORS
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attendance
dataset
unknown_f
absentees.p
all_students
analytics.py
capture.py
face-train.p
labels.pickl
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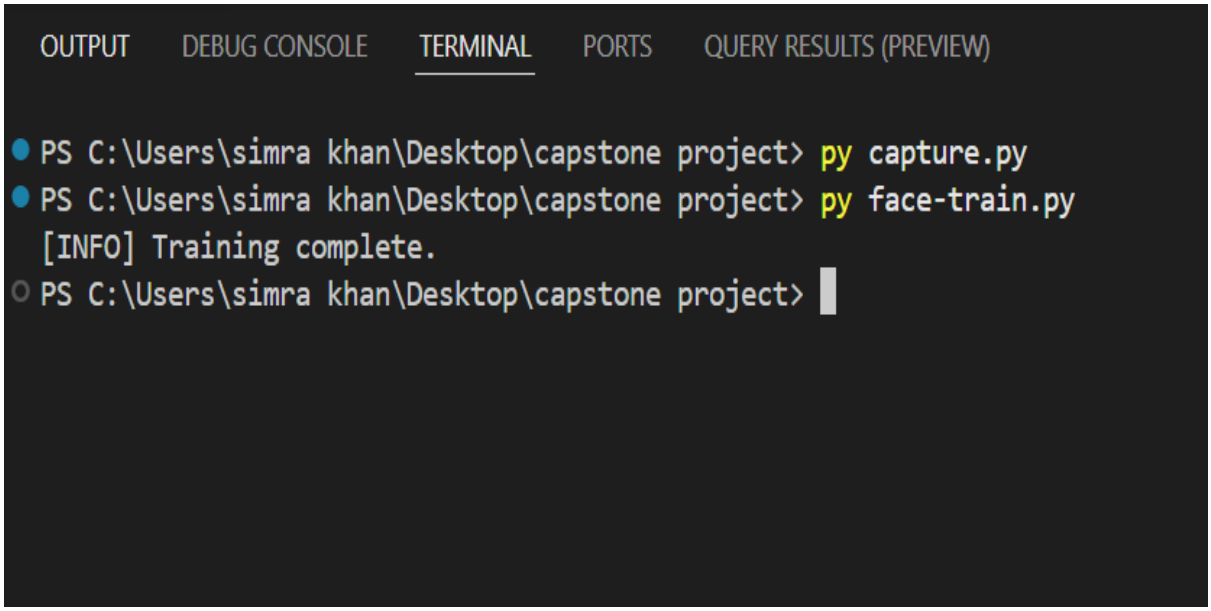
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
QUERY RESULTS (PREVIEW)
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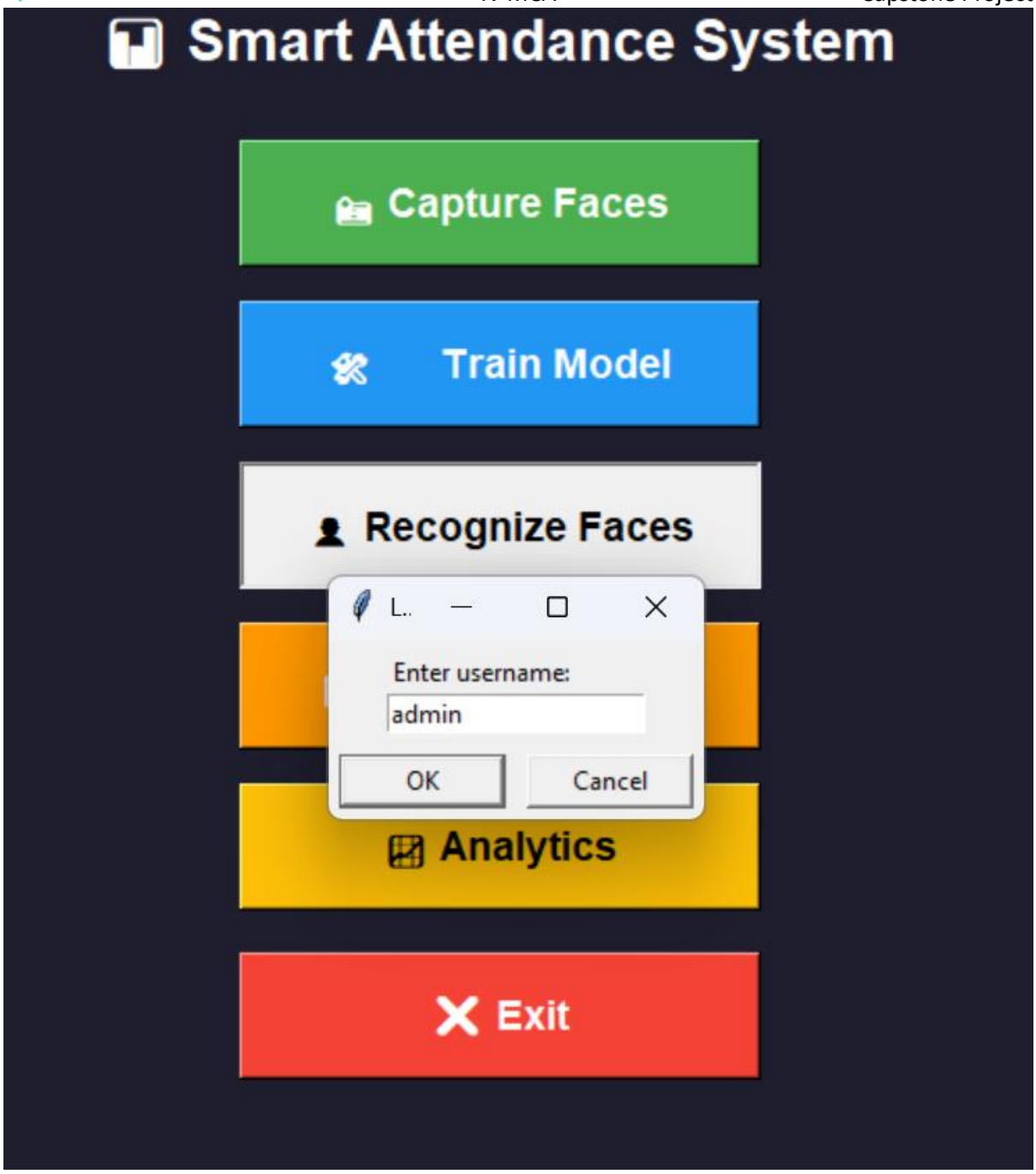
Smart Attendance System
Capture Faces
Train Model
Recognize Faces
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Enter username:
admin
OK
Cancel
Analytics
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L..
Enter password:
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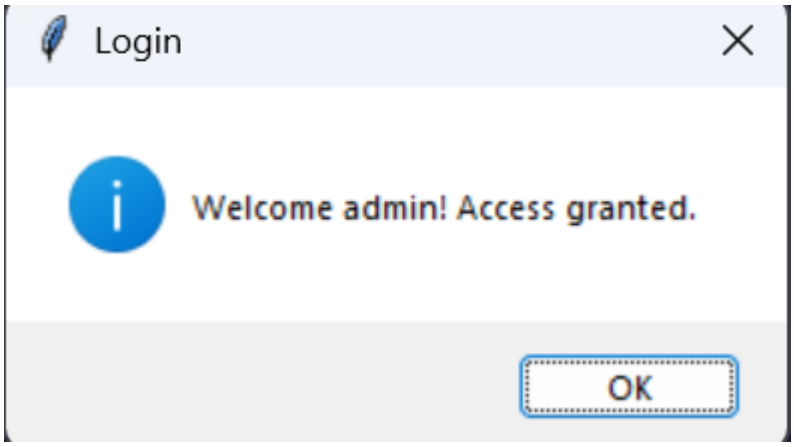
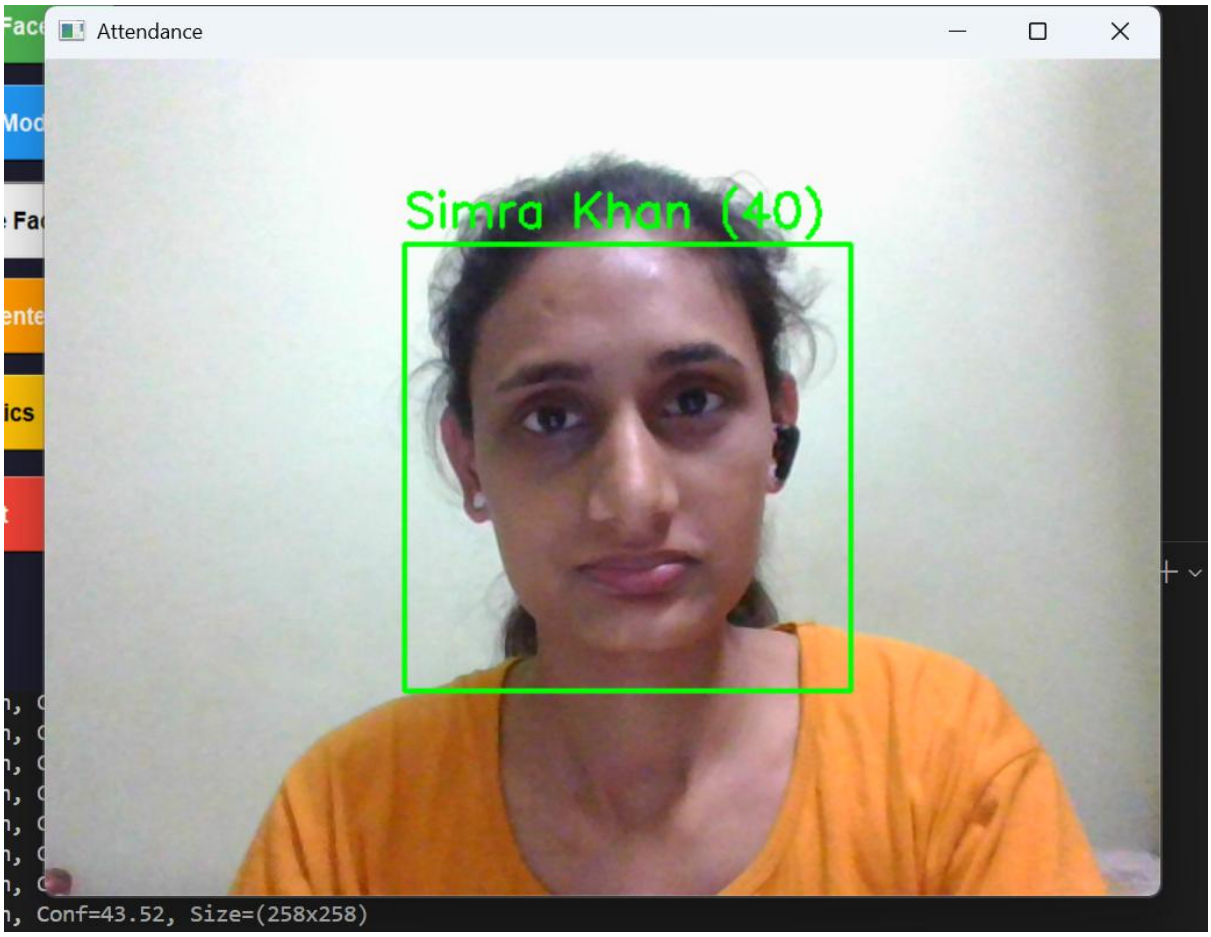
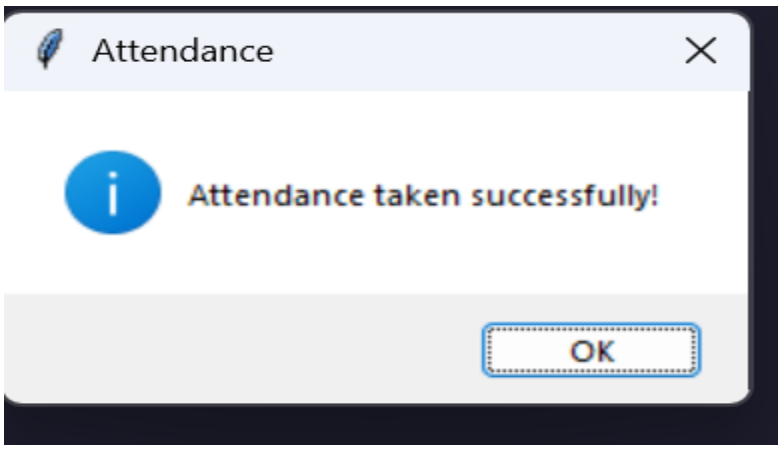
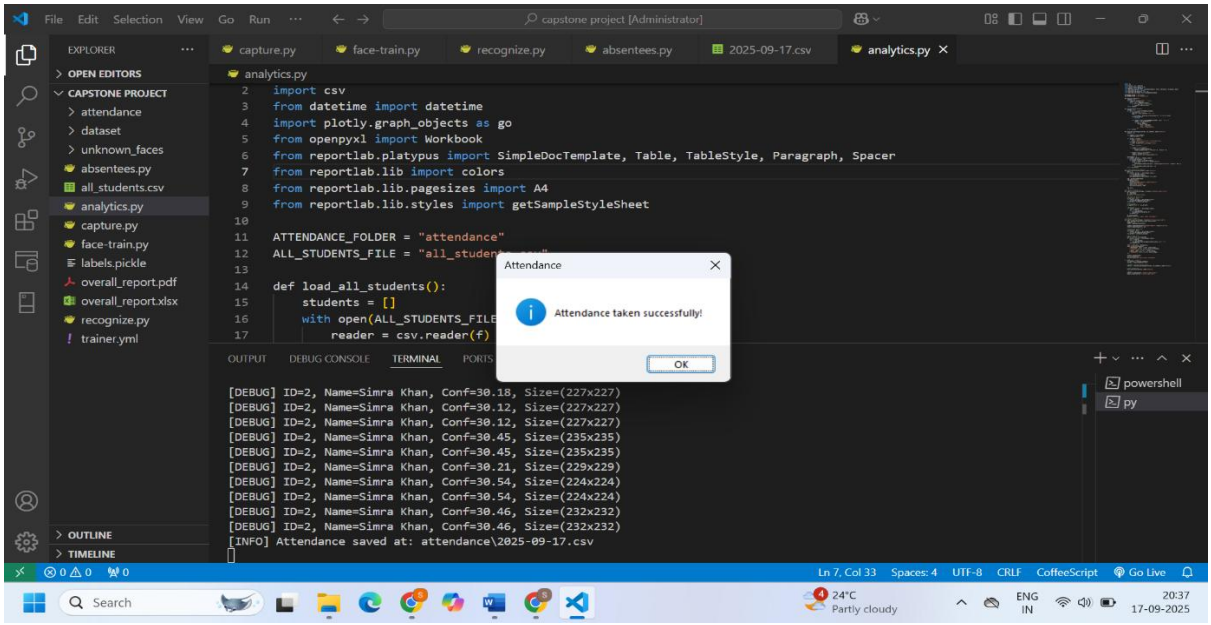
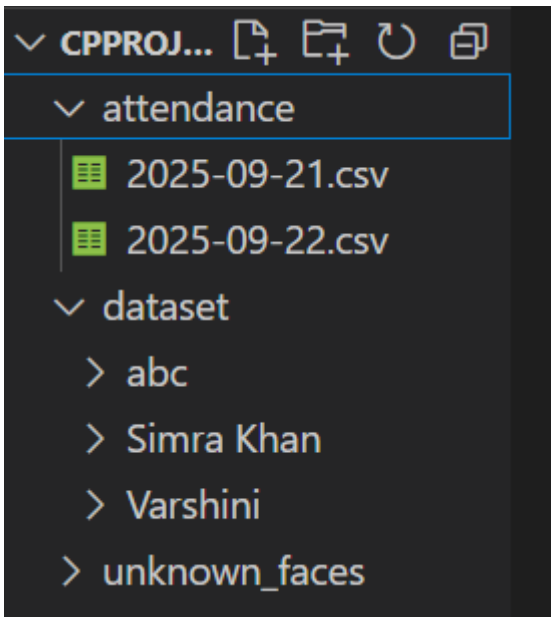

Login
Welcome admin! Access granted.
OK


Attendance
Simra Khan (40)
Conf=43.52, Size=(258x258)

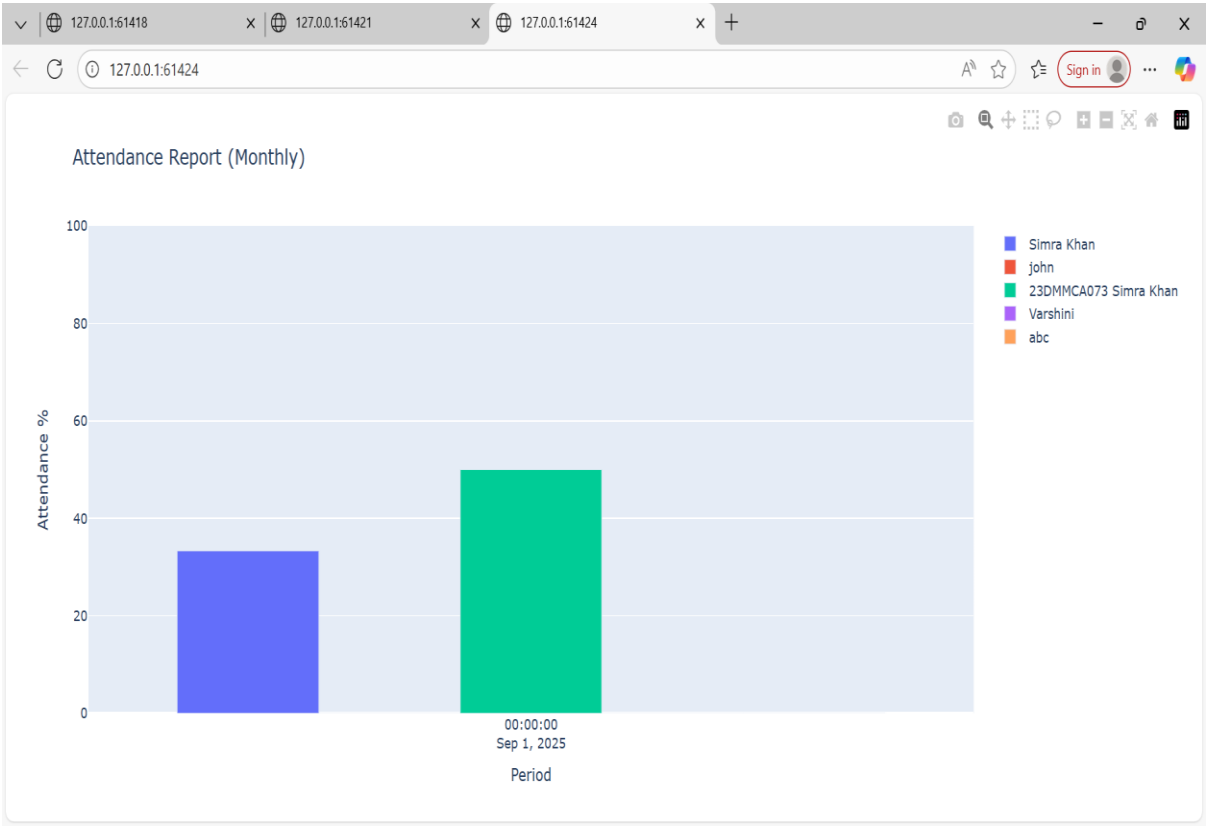

Attendance
Attendance taken successfully!
OK

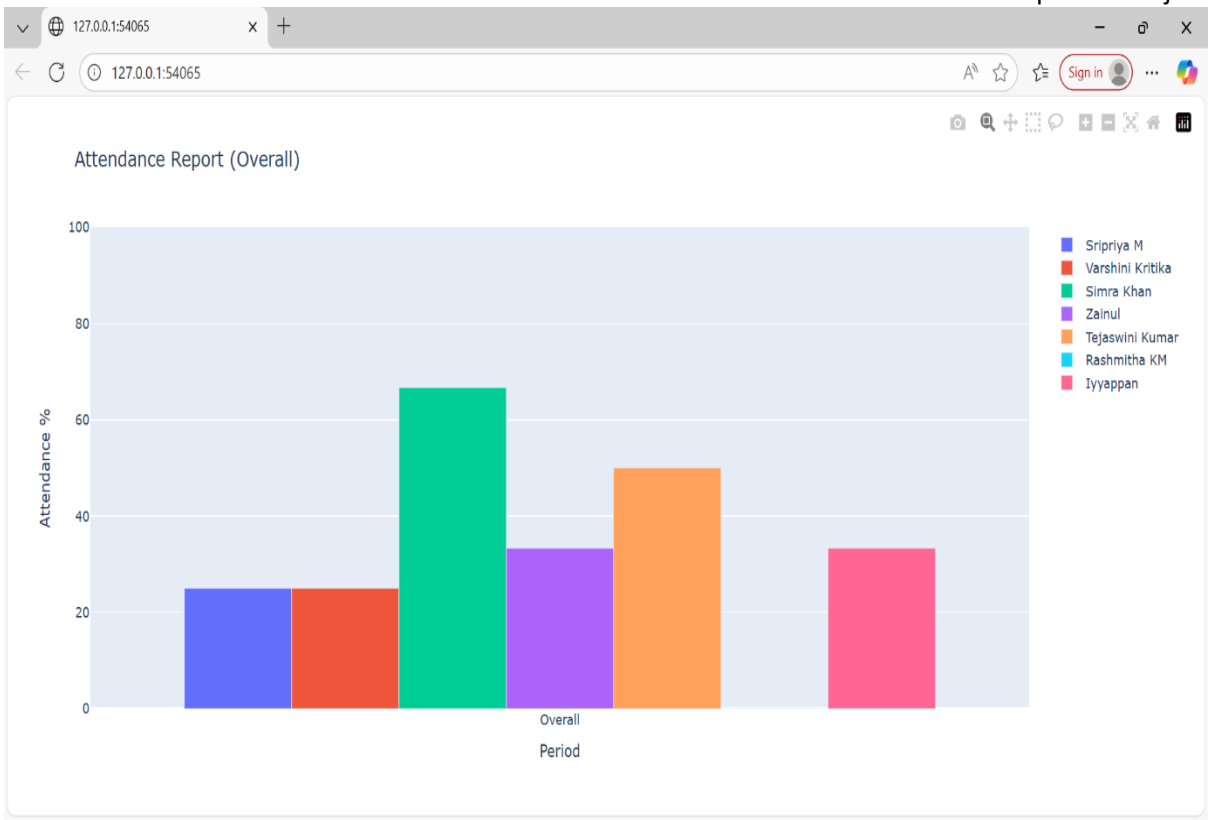

File Edit Selection View Go Run
capstone project [Administrator]
EXPLORER
OPEN EDITORS
CAPSTONE PROJECT
attendance
dataset
unknown_faces
absentees.py
all_students.csv
analytics.py
capture.py
face-train.py
labels.pickle
overall_report.pdf
overall_report.xlsx
recognize.py
trainer.yml
capture.py
face-train.py
recognize.py
absentees.py
2025-09-17.csv
analytics.py
import csv
from datetime import datetime
import plotly.graph_objects as go
from openpyxl import Workbook
from reportlab.platypus import SimpleDocTemplate, Table, TableStyle, Paragraph, Spacer
from reportlab.lib import colors
from reportlab.lib.pagesizes import A4
from reportlab.lib.styles import getSampleStyleSheet
ATTENDANCE_FOLDER = "attendance"
def load_all_students():
students = []
reader = csv.reader(f)
Attendance
Attendance taken successfully!
OK
OUTPUT DEBUG CONSOLE TERMINAL PORTS
[DEBUG] ID=2, Name=Simra Khan, Conf=30.18, Size=(227x227)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.12, Size=(227x227)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.12, Size=(227x227)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.45, Size=(235x235)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.45, Size=(235x235)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.21, Size=(229x229)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.54, Size=(224x224)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.54, Size=(224x224)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.46, Size=(232x232)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.46, Size=(232x232)
[INFO] Attendance saved at: attendance\2025-09-17.csv
powershell
py
OUTLINE
TIMELINE
Ln 7, Col 33 Spaces: 4 UTF-8 CRLF CoffeeScript Go Live
Search
24°C Partly cloudy
ENG IN
20:37 17-09-2025

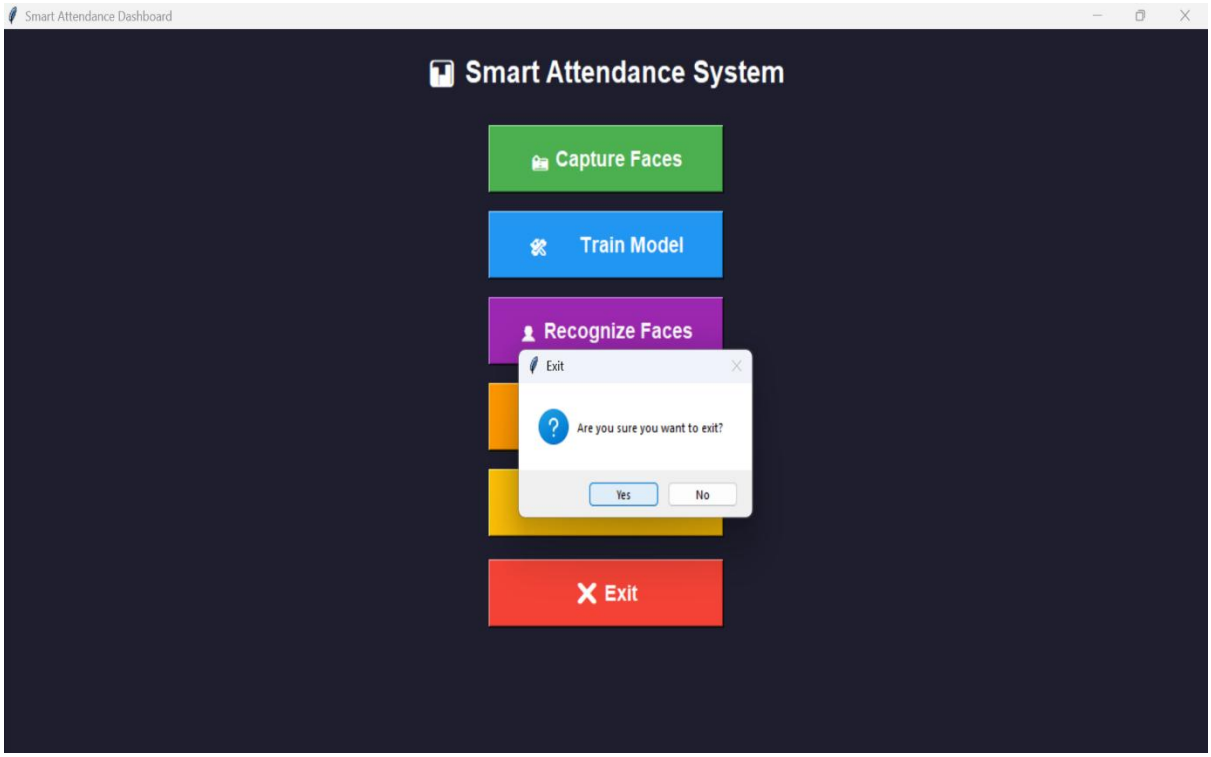

CPPROJ...
attendance
2025-09-21.csv
2025-09-22.csv
dataset
abc
Simra Khan
Varshini
unknown_faces

```
OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS  QUERY RESULTS (PREVIEW)

[DEBUG] ID=2, Name=Simra Khan, Conf=31.35, Size=(210x210)
[DEBUG] ID=2, Name=Simra Khan, Conf=31.17, Size=(210x210)
[DEBUG] ID=2, Name=Simra Khan, Conf=31.17, Size=(210x210)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.68, Size=(213x213)
[DEBUG] ID=2, Name=Simra Khan, Conf=30.68, Size=(213x213)
[INFO] Attendance saved at: attendance\2025-09-17.csv
PS C:\Users\simra khan\Desktop\capstone project> py absentees.py
[INFO] Absentees marked successfully in attendance\2025-09-17.csv
PS C:\Users\simra khan\Desktop\capstone project> py analytics.py
[INFO] Excel report saved: overall_report.xlsx
[INFO] PDF report saved: overall_report.pdf
PS C:\Users\simra khan\Desktop\capstone project>
```




127.0.0.1:54065
127.0.0.1:54065
Sign in
Attendance Report (Overall)
100
80
60
40
20
0
Attendance %
Overall
Period
Sripriya M
Varshini Kritika
Simra Khan
Zainul
Tejaswini Kumar
Rashmitha KM
Iyyappan


Smart Attendance Dashboard
Smart Attendance System
Capture Faces
Train Model
Recognize Faces
Exit
Are you sure you want to exit?
Yes
No
Exit

6. CODING

6.1 Module 1 - capture.py:- The capture.py script is designed to capture face images of students using a webcam and store them in a dataset for training a face recognition model.

- It first asks the user (via a Tkinter dialog box) to enter the student's name.
- A dedicated folder with the student's name is created inside the dataset directory.
- The student's name is also recorded in the file all_students.csv (to maintain a master list of all registered students).
- The webcam is then activated, and the live video feed is displayed.
- The user can press 's' to save a captured image of the face, or 'q' to quit the capture process.
- A maximum of 30 images per student can be saved, which are later used to train the recognition model.

This script registers new students by capturing and saving their face images into the dataset for training purposes.

CODE

```
import cv2
import os
from tkinter import simpledialog, messagebox, Tk
import csv
dataset_dir = "dataset"
os.makedirs(dataset_dir, exist_ok=True)
def update_all_students(name):
    file_path = "all_students.csv"
    if not os.path.exists(file_path):
        with open(file_path, 'w', newline='') as f:
            writer = csv.writer(f)
            writer.writerow(["Name"])
    # read existing names
    with open(file_path, 'r', newline='') as f:
        reader = csv.reader(f)
        names = [row[0] for i,row in enumerate(reader) if i>0 and row]
    if name not in names:
```

```
        with open(file_path, 'a', newline='') as f:
            csv.writer(f).writerow([name])
def capture_images():
    root = Tk()
    root.withdraw()
    name = simpledialog.askstring("Input", "Enter name of person:")
    if not name:
        messagebox.showerror("Error", "Name is required")
        return
    person_dir = os.path.join(dataset_dir, name)
    os.makedirs(person_dir, exist_ok=True)
    update_all_students(name)
    cap = cv2.VideoCapture(0)
    count=0
    print("[INFO] Press 's' to save an image, 'q' to quit (or stop after 30 saves).")
    while True:
        ret, frame = cap.read()
        if not ret:
            break
        cv2.imshow("Capture - Press 's' to save, 'q' to quit", frame)
        key = cv2.waitKey(1) & 0xFF
        if key == ord('s'):
            filename = os.path.join(person_dir, f"{name}_{count}.jpg")
            cv2.imwrite(filename, frame)
            count += 1
            print(f"[INFO] Saved {filename}")
        elif key == ord('q') or count>=30:
            break
    cap.release()
    cv2.destroyAllWindows()
```

```
if __name__ == "__main__":
    capture_images()
```

6.2 Module 2 - train.py :- The train.py script is responsible for training the face recognition model using the images captured in the dataset.

- It scans through the dataset directory, where each student has their own folder of face images.
- Each folder name (student's name) is converted into a numeric label ID and stored in a dictionary (labels.pickle).
- For every image, the script:
  - Converts it to grayscale.
  - Detects faces using Haar Cascade Classifier.
  - Extracts and resizes the face region (ROI) to a uniform size (200×200).
- The processed face images (x_train) and their corresponding labels (y_labels) are then used to train an LBPH (Local Binary Patterns Histogram) Face Recognizer.
- Finally, the trained model is saved as trainer.yml, and the label mapping is stored in labels.pickle for future recognition.

This script processes the collected face dataset, assigns labels, and trains an LBPH face recognition model for identifying students.

CODE

```
import cv2
import os
import numpy as np
import pickle
face_cascade = cv2.CascadeClassifier(cv2.data.haarcascades + "haarcascade_frontalface_default.xml")
BASE_DIR = "dataset"
label_ids = {}
current_id = 0
x_train = []
y_labels = []
for root, dirs, files in os.walk(BASE_DIR):
    for file in files:
```

```
    if file.lower().endswith(('jpg','jpeg','png')):
        path = os.path.join(root, file)
        label = os.path.basename(root)
        if label not in label_ids:
            label_ids[label] = current_id
            current_id += 1
        id_ = label_ids[label]
        img = cv2.imread(path, cv2.IMREAD_GRAYSCALE)
        if img is None:
            print(f"[WARN] Could not read {path}")
            continue
            faces = face_cascade.detectMultiScale(img, scaleFactor=1.1, minNeighbors=5, minSize=(50,50))
        for (x, y, w, h) in faces:
            roi = img[y:y+h, x:x+w]
            roi_resized = cv2.resize(roi, (200, 200))
            x_train.append(roi_resized)
            y_labels.append(id_)
with open("labels.pickle", "wb") as f:
  pickle.dump(label_ids, f)
recognizer = cv2.face.LBPHFaceRecognizer_create()
recognizer.train(x_train, np.array(y_labels))
recognizer.save("trainer.yml")
print("[INFO] Training complete. Saved trainer.yml and labels.pickle")
```

6.3 Module 3 – recognize.py :-The recognize.py script is the core module of the Smart Attendance System, responsible for real-time face recognition and attendance marking.

- Staff Authentication: Before starting, the system asks for a valid username and password (from staff.csv or defaults) to ensure only authorized users can run attendance.
- Model Loading: It loads the trained LBPH model (trainer.yml) and the label mapping (labels.pickle) to recognize students.

- Dataset & Attendance Setup: Reads the list of registered students (all_students.csv) and prepares a new daily attendance file inside the attendance/ folder.
- Face Recognition:
    - Activates the webcam and detects faces using the Haar Cascade classifier.
    - Recognizes faces using the LBPH recognizer, displaying the student's name and confidence score on screen.
    - Marks recognized students as "Present" and stores them in memory.
- Unknown Face Handling: If an unregistered or unclear face is detected, it is labeled as "Unknown." To avoid duplicates, only distinct unknown faces are saved (in unknown_faces/) at intervals of 10 seconds.
- Attendance File Generation: At the end of recognition (when the user quits), the system writes a CSV file containing the list of all students, marking them as either "Present" or "Absent."
- User Feedback: Shows a final confirmation message that attendance has been successfully recorded.

This script performs real-time face recognition, ensures security with staff login, handles unknown faces smartly, and automatically generates a daily attendance report.

CODE

```
import cv2
import pickle
import csv
import os
import time
import numpy as np
from datetime import datetime
import tkinter as tk
from tkinter import simpledialog, messagebox
# --- Authentication (fallback if staff.csv missing) ---
STAFF_FILE = "staff.csv"
def authenticate_staff():
    default_staff = {"admin":"admin123"}
    staff = default_staff.copy()
    if os.path.exists(STAFF_FILE):
```

```
        try:
            with open(STAFF_FILE, 'r', newline='') as f:
                reader = csv.DictReader(f)
                for row in reader:
                    # accept multiple header variants
                    username = row.get('username') or row.get('Username') or row.get('user') or None
                    password = row.get('password') or row.get('Password') or row.get('pass') or None
                    if username and password:
                        staff[username] = password
        except Exception as e:
            print(f"[WARN] could not read {STAFF_FILE}: {e}")
    root = tk.Tk(); root.withdraw()
    username = simpledialog.askstring("Login", "Enter username:")
    password = simpledialog.askstring("Login", "Enter password:", show="*")
    if username in staff and staff[username] == password:
        messagebox.showinfo("Login", f"Welcome {username}! Access granted.")
        return True
    else:
        messagebox.showerror("Login Failed", "Invalid credentials! Access denied.")
        return False
if not authenticate_staff():
    raise SystemExit(0)
# --- Load recognizer and labels ---
if not os.path.exists('trainer.yml') or not os.path.exists('labels.pickle'):
    messagebox.showerror('Missing Files', 'trainer.yml and/or labels.pickle not found. Run train_recognizer.py first.')
    raise SystemExit(0)
recognizer = cv2.face.LBPHFaceRecognizer_create()
recognizer.read("trainer.yml")
with open("labels.pickle", 'rb') as f:
    original_labels = pickle.load(f)
```

```
    labels = {v: k for k, v in original_labels.items()}

# --- Load Haar Cascade ---

face_cascade = cv2.CascadeClassifier(cv2.data.haarcascades + 'haarcascade_frontalface_default.xml')

# --- Attendance folder setup ---

date_str = datetime.now().strftime("%Y-%m-%d")

attendance_path = os.path.join("attendance", f"{date_str}.csv")

os.makedirs("attendance", exist_ok=True)

# --- Load all students ---

if not os.path.exists('all_students.csv'):

      messagebox.showerror('Missing', 'all_students.csv not found. Please create or run capture_images.py first.')

    raise SystemExit(0)


with open("all_students.csv", 'r', newline='') as f:

    reader = csv.reader(f)

    all_students = set()

    for i,row in enumerate(reader):

        if i==0: continue

        if row:

            all_students.add(row[0].strip())

present_students = set()

# --- Webcam capture ---

cap = cv2.VideoCapture(0)

if not cap.isOpened():

   messagebox.showerror('Camera Error', 'Could not open webcam. Check camera permissions and device index.')

    raise SystemExit(0)

print("[INFO] Recognizing faces... Press 'q' to quit")

# --- Unknown face tracking ---

last_unknown_time = 0
```

```
last_unknown_face = None
def mse(imageA, imageB):
    err = np.sum((imageA.astype("float") - imageB.astype("float")) ** 2)
    err /= float(imageA.shape[0] * imageA.shape[1])
    return err
def apply_clahe(gray):
    clahe = cv2.createCLAHE(clipLimit=2.0, tileGridSize=(8,8))
    return clahe.apply(gray)
while True:
    ret, frame = cap.read()
    if not ret:
        break
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
    gray = apply_clahe(gray)
    faces = face_cascade.detectMultiScale(
        gray,
        scaleFactor=1.1,
        minNeighbors=6,
        minSize=(100, 100)
    )
    for (x, y, w, h) in faces:
        roi_gray = gray[y:y+h, x:x+w]
        # ensure ROI large enough
        try:
            id_, conf = recognizer.predict(roi_gray)
        except Exception as e:
            print("[WARN] recognizer prediction failed:", e)
            continue
        # Debug info
            print(f"[DEBUG] ID={id_}, Name={labels.get(id_, 'Unknown')}, Conf={conf:.2f},
Size=({w}x{h})")
```

```
        if conf <= 70 and w > 120 and h > 120:
            name = labels.get(id_, "Unknown")
            color = (0, 255, 0)
            if name not in present_students:
                present_students.add(name)
                print(f"[MARKED PRESENT] {name}")
        else:
            name = "Unknown"
            color = (0, 0, 255)
            now = time.time()
            if now - last_unknown_time > 10:
                unknown_dir = "unknown_faces"
                os.makedirs(unknown_dir, exist_ok=True)
                face_resized = cv2.resize(roi_gray, (100, 100))
                save_face = True
                if last_unknown_face is not None:
                    error = mse(face_resized, last_unknown_face)
                    if error < 100:
                        save_face = False
                        print("[INFO] Skipped duplicate unknown face.")
                if save_face:
                    timestamp = datetime.now().strftime("%Y%m%d_%H%M%S%f")
                    fname = os.path.join(unknown_dir, f"unknown_{timestamp}.jpg")
                    cv2.imwrite(fname, face_resized)
                    last_unknown_face = face_resized
                    last_unknown_time = now
                    print(f"[INFO] Unknown face saved: {fname}")
        cv2.rectangle(frame, (x, y), (x+w, y+h), color, 2)
        cv2.putText(frame, f"{name} ({conf:.0f})", (x, y-10), cv2.FONT_HERSHEY_SIMPLEX,
0.9, color, 2)
    cv2.imshow("Attendance", frame)
```

```
    if cv2.waitKey(1) & 0xFF == ord('q'):
        break
cap.release()
cv2.destroyAllWindows()
# --- Save attendance ---
absent_students = all_students - present_students
with open(attendance_path, 'w', newline='') as f:
    writer = csv.writer(f)
    writer.writerow(["Name", "Status"])
    for name in sorted(present_students):
        writer.writerow([name, "Present"])
    for name in sorted(absent_students):
        writer.writerow([name, "Absent"])
print("[INFO] Attendance saved at:", attendance_path)
tk.Tk().withdraw()
messagebox.showinfo("Attendance", "Attendance taken successfully!")
```

6.4 Module 4 – Absentees.py :- The absentees.py script is designed to identify and mark absent students in the daily attendance file.

- It first loads the complete list of students from all_students.csv.
- It then checks the attendance file for today (e.g., attendance/YYYY-MM-DD.csv) to see which students have already been marked "Present."
- Any student not found in the present list is considered "Absent."
- The script updates the daily attendance file by adding these absentees with the current time and Status = Absent.
- If all students are present, it displays "No absentees to mark."

This script ensures that all students not recognized during attendance are explicitly marked as "Absent" in the daily attendance record.

CODE

```
import csv
import os
from datetime import date, datetime
```

```
ATTENDANCE_FOLDER = 'attendance'
ALL_STUDENTS_FILE = 'all_students.csv'
def get_today_filename():
    today_str = date.today().strftime('%Y-%m-%d')
    return os.path.join(ATTENDANCE_FOLDER, f'{today_str}.csv')
def load_all_students():
    students = []
    with open(ALL_STUDENTS_FILE, 'r') as f:
        reader = csv.reader(f)
        next(reader, None)  # skip header
        for row in reader:
            if row:
                students.append(row[0].strip())
    return students
def load_present_students(file_path):
    present = set()
    if not os.path.exists(file_path):
        return present
    with open(file_path, 'r') as f:
        reader = csv.DictReader(f)
        for row in reader:
            if 'Name' in row and 'Status' in row:
                if row['Status'].strip().lower() == 'present':
                    present.add(row['Name'].strip())
    return present
def mark_absentees():
    all_students = load_all_students()
    today_file = get_today_filename()
    present_students = load_present_students(today_file)
    absentees = [name for name in all_students if name not in present_students]
```

```
    if not absentees:
        print("No absentees to mark.")
        return
    existing_rows = []
    if os.path.exists(today_file):
        with open(today_file, 'r') as f:
            reader = csv.DictReader(f)
            for row in reader:
                existing_rows.append(row)
    now = datetime.now().strftime('%H:%M')
    for name in absentees:
        existing_rows.append({'Name': name, 'Time': now, 'Status': 'Absent'})
    with open(today_file, 'w', newline='') as f:
        fieldnames = ['Name', 'Time', 'Status']
        writer = csv.DictWriter(f, fieldnames=fieldnames)
        writer.writeheader()
        for row in existing_rows:
            writer.writerow(row)
    print(f"[INFO] Absentees marked successfully in {today_file}")
if __name__ == '__main__':
    mark_absentees()
```

6.5 Module 5 – Analytics.py :- The analytics.py script is responsible for analyzing and visualizing attendance records.

- It loads the list of students and all attendance CSV files stored in the attendance folder.
- It processes the data to calculate attendance percentages for each student in three modes:
    - Overall (entire duration)
    - Weekly (attendance percentage per week)
    - Monthly (attendance percentage per month)
- It then generates interactive bar charts using Plotly to visualize attendance trends.

- Additionally, it allows exporting the summarized reports into:
    - Excel files (.xlsx) for structured tabular data.
    - PDF files for professional, printable attendance reports.

module provides detailed analytics, charts, and downloadable reports of student attendance in multiple formats.

CODE

```
import os
import csv
from datetime import datetime
import plotly.graph_objects as go
from openpyxl import Workbook
from reportlab.platypus import SimpleDocTemplate, Table, TableStyle, Paragraph, Spacer
from reportlab.lib import colors
from reportlab.lib.pagesizes import A4
from reportlab.lib.styles import getSampleStyleSheet
ATTENDANCE_FOLDER = "attendance"
ALL_STUDENTS_FILE = "all_students.csv"
def load_all_students():
    students = []
    with open(ALL_STUDENTS_FILE, 'r') as f:
        reader = csv.reader(f)
        for i, row in enumerate(reader):
            if i > 0 and row:  # skip header
                students.append(row[0])
    return students
def load_attendance_files():
    records = []
    for file in os.listdir(ATTENDANCE_FOLDER):
        if file.endswith(".csv"):
            date_str = file.replace(".csv", "")
            try:
```

```
            file_date = datetime.strptime(date_str, "%Y-%m-%d").date()
        except ValueError:
            continue

        with open(os.path.join(ATTENDANCE_FOLDER, file), 'r') as f:
            reader = csv.DictReader(f)
            for row in reader:
                records.append({
                    "date": file_date,
                    "name": row.get("Name"),
                    "status": row.get("Status")
                })
    return records
def calculate_percentages(records, all_students, mode="overall"):
    summary = {}
    for student in all_students:
        summary[student] = {}
    for record in records:
        if mode == "weekly":
            key = f"Week-{record['date'].isocalendar()[1]}"
        elif mode == "monthly":
            key = record["date"].strftime("%Y-%m")
        else:
            key = "Overall"
        for student in all_students:
            if key not in summary[student]:
                summary[student][key] = {"Present": 0, "Absent": 0}
        if record["name"] in all_students:
            status = record["status"]
            summary[record["name"]][key][status] += 1
```

```
    percentages = {}
    for student, periods in summary.items():
        percentages[student] = {}
        for period, counts in periods.items():
            total = counts["Present"] + counts["Absent"]
            if total > 0:
                percentages[student][period] = round((counts["Present"] / total) * 100, 2)
            else:
                percentages[student][period] = 0.0
    return percentages
def plot_interactive(percentages, mode="overall"):
    data = []
    for student, periods in percentages.items():
        x = list(periods.keys())
        y = list(periods.values())
        data.append(go.Bar(name=student, x=x, y=y))
    fig = go.Figure(data=data)
    fig.update_layout(
        barmode="group",
        title=f"Attendance Report ({mode.title()})",
        xaxis_title="Period",
        yaxis_title="Attendance %",
        yaxis=dict(range=[0, 100])
    )
    fig.show()
def export_to_excel(percentages, filename):
    wb = Workbook()
    ws = wb.active
    ws.title = "Attendance Report"
    all_periods = set()
```

```
    for student, periods in percentages.items():
        all_periods.update(periods.keys())
    all_periods = sorted(all_periods)
    ws.append(["Name"] + all_periods)
    for student, periods in percentages.items():
        row = [student]
        for p in all_periods:
            row.append(periods.get(p, 0))
        ws.append(row)
    wb.save(filename)
    print(f"[INFO] Excel report saved: {filename}")
def export_to_pdf(percentages, filename):
    doc = SimpleDocTemplate(filename, pagesize=A4)
    elements = []
    styles = getSampleStyleSheet()
    elements.append(Paragraph("Attendance Report", styles['Title']))
    elements.append(Spacer(1, 12))
    all_periods = set()
    for student, periods in percentages.items():
        all_periods.update(periods.keys())
    all_periods = sorted(all_periods)
    data = [["Name"] + all_periods]
    for student, periods in percentages.items():
        row = [student]
        for p in all_periods:
            row.append(str(percentages[student].get(p, 0)) + "%")
        data.append(row)
    table = Table(data, repeatRows=1)
    table.setStyle(TableStyle([
        ("BACKGROUND", (0,0), (-1,0), colors.grey),
```

```
        ("TEXTCOLOR", (0,0), (-1,0), colors.whitesmoke),
        ("ALIGN", (0,0), (-1,-1), "CENTER"),
        ("GRID", (0,0), (-1,-1), 1, colors.black),
        ("BACKGROUND", (0,1), (-1,-1), colors.beige),
    ]))
    elements.append(table)
    doc.build(elements)
    print(f"[INFO] PDF report saved: {filename}")
if __name__ == "__main__":
    all_students = load_all_students()
    records = load_attendance_files()
    for mode in ["overall", "weekly", "monthly"]:
        print(f"\n[INFO] Generating {mode.title()} Report...")
        percentages = calculate_percentages(records, all_students, mode=mode)
        plot_interactive(percentages, mode=mode)
        export_to_excel(percentages, f"{mode}_report.xlsx")
        export_to_pdf(percentages, f"{mode}_report.pdf")
```

6.6 Module 6 – Dashboard.py :- The dashboard.py script serves as the Graphical User Interface (GUI) for the Smart Attendance System.

- It provides a centralized dashboard using Python's Tkinter library.
- The interface includes buttons for all major functionalities:
    - Capture Faces → Runs capture.py to collect student images.
    - Train Model → Runs train.py to train the face recognition model.
    - Recognize Faces → Runs recognize.py to take attendance through face recognition.
    - Mark Absentees → Runs absentees.py to update absent students.
    - Analytics → Runs analytics.py to generate attendance reports.
    - Exit → Safely closes the application.
- It features a user-friendly interface with styled buttons, icons (emojis), and a professional title for better usability.

This module acts as the main control panel, allowing users to access all system functionalities from a single window.

CODE

```
import tkinter as tk
from tkinter import messagebox
import os
# --- Functions for each button ---
def capture_faces():
    os.system("py capture.py")
def train_faces():
    os.system("py train.py")
def recognize_faces():
    os.system("py recognize.py")
def mark_absentees():
    os.system("py absentees.py")
def show_analytics():
    os.system("py analytics.py")
def exit_app():
    if messagebox.askyesno("Exit", "Are you sure you want to exit?"):
        root.destroy()
# --- Dashboard Window ---
root = tk.Tk()
root.title("Smart Attendance Dashboard")
root.geometry("500x450")
root.config(bg="#1e1e2f")
# --- Title ---
title = tk.Label(root, text="📊 Smart Attendance System",
                 font=("Arial", 20, "bold"), bg="#1e1e2f", fg="white")
title.pack(pady=20)
# --- Buttons ---
btn_style = {"font": ("Arial", 14, "bold"), "width": 20, "height": 2}
tk.Button(root, text="📸 Capture Faces", bg="#4CAF50", fg="white",
```

```
        command=capture_faces, **btn_style).pack(pady=8)
tk.Button(root, text="🛠️ Train Model", bg="#2196F3", fg="white",
        command=train_faces, **btn_style).pack(pady=8)
tk.Button(root, text="👤 Recognize Faces", bg="#9C27B0", fg="white",
        command=recognize_faces, **btn_style).pack(pady=8)
tk.Button(root, text="📋 Mark Absentees", bg="#FF9800", fg="white",
        command=mark_absentees, **btn_style).pack(pady=8)
tk.Button(root, text="📈 Analytics", bg="#FFC107", fg="black",
        command=show_analytics, **btn_style).pack(pady=8)
tk.Button(root, text="❌ Exit", bg="#F44336", fg="white",
        command=exit_app, **btn_style).pack(pady=12)
# --- Run ---
root.mainloop()
```

7. TESTING

Testing is a critical phase of the software development life cycle (SDLC). It ensures that the developed system functions correctly, meets user requirements, and is free of defects before deployment. For the Smart Attendance System, different levels of testing were conducted: Unit Testing, Integration Testing, System Testing, and Acceptance Testing. Each level addressed different aspects of software validation, starting from testing small modules to ensuring the entire system works end-to-end.

7.1 Unit Testing

Unit testing involves testing individual modules or components of the system in isolation, without considering interactions with other modules. The goal is to ensure that each module works according to its design specifications.

In this project, every Python script was treated as a unit and tested separately:

- **Capture Module (capture.py):** Tested whether it correctly accepts a student's name, creates a dataset folder, and saves multiple face images. The correctness of CSV updates (all_students.csv) was also verified.
- **Training Module (train.py):** Tested whether images were properly converted into grayscale, faces were detected, and the LBPH recognizer successfully generated trainer.yml and labels.pickle.
- **Recognition Module (recognize.py):** Checked whether the recognizer correctly identified registered students and stored unknown faces in the unknown_faces/ folder.
- **Absentees Module (absentees.py):** Verified that absent students were marked accurately by comparing the daily attendance file with the master list.
- **Analytics Module (analytics.py):** Validated that attendance percentages were calculated correctly and that Excel/PDF reports were generated in the right format.
- **Dashboard Module (dashboard.py):** Tested whether each button successfully launched its respective module without crashes.

Why this matters: Unit testing helped detect early-stage bugs, such as incorrect file naming in capture.py and CSV misalignment in absentees.py. Fixing these early prevented major integration problems later.

7.2 Integration Testing

Integration testing focuses on the interaction between modules to ensure data flows correctly across the system. Even if individual modules work properly, errors can occur when they are connected together.

For this project, integration testing verified scenarios like:

1. **Capture → Train:** Ensured that images captured by the capture module were compatible with the training module. A mismatch in image resolution or improper dataset labeling could have caused errors in training.
2. **Train → Recognize:** Confirmed that the trained model (trainer.yml) could be successfully loaded by the recognition module.
3. **Recognize → Absentees:** Verified that attendance marked by the recognition module was seamlessly passed to the absentee module for missing student identification.
4. **Attendance → Analytics:** Tested that the daily attendance files generated could be processed by the analytics module to produce graphs and reports.
5. **Dashboard → All Modules:** Validated that the dashboard served as a central hub, ensuring smooth navigation between capture, training, recognition, absentee, and analytics features.

Why this matters: During integration testing, minor issues were detected. For example, initially, the training module expected images in grayscale, but some images were saved in color during capture. This mismatch was corrected by adding automatic grayscale conversion in the capture module. Such fixes ensured seamless integration across the pipeline.

7.3 System Testing

System testing evaluates the entire system as a whole, ensuring both functional and non-functional requirements are satisfied. It is a black-box testing method where the internal code is not examined; instead, the system is tested based on expected outputs.

Functional Testing

- Verified that students could be registered, trained, recognized, and attendance generated in CSV format.
- Confirmed that absentee records were added automatically.
- Checked that analytics correctly produced bar charts and reports in Excel/PDF formats.

Performance Testing

- Tested the system with 50+ registered students. Recognition accuracy was maintained, and attendance files were generated within seconds.
- Webcam processing speed was tested in real-time, and the system successfully processed frames at acceptable speed for classroom use.

Error Handling Testing

- Attempted to run recognition without a trained model (trainer.yml). The system displayed an appropriate error message instead of crashing.
- Tested wrong staff login credentials to ensure unauthorized users could not access the recognition module.

Security Testing

- Staff authentication before recognition was checked thoroughly. Only valid credentials allowed access, ensuring controlled use.
- Unknown faces were successfully saved for review in the unknown_faces/ folder, preventing fraudulent attendance.

Why this matters: System testing validated that the Smart Attendance System not only works correctly but is also robust under various conditions, including large datasets, missing files, and unauthorized access.

7.4 Acceptance Testing

Acceptance testing determines whether the system meets the requirements and expectations of the end-users. It is the final phase of testing before deployment.

Process:

Acceptance testing was conducted with staff members who would use the system in real classroom environments. The following activities were performed:

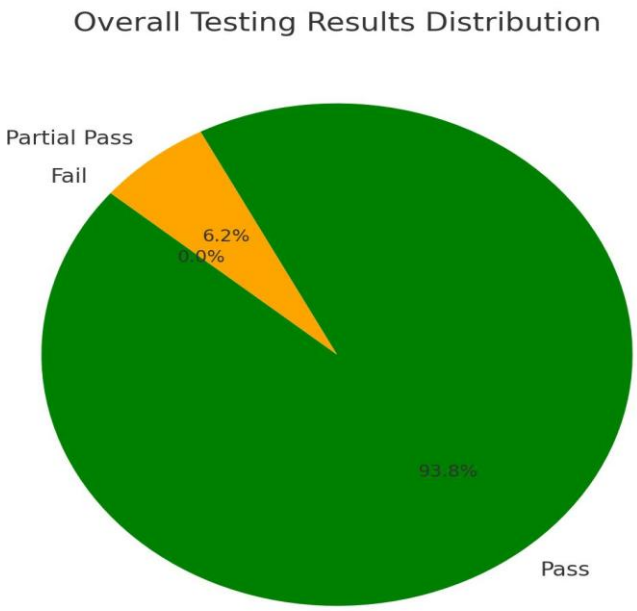
1. Staff registered a new student using the capture module.
2. Training was performed, and the student's face was recognized in real-time.
3. Attendance was automatically recorded, and absentees were marked.
4. Analytics reports were generated and reviewed for usability.

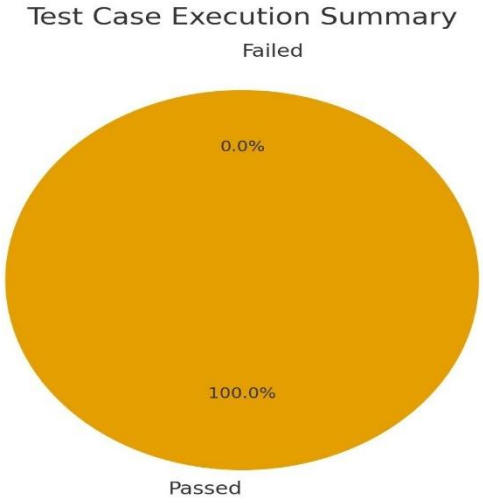
Feedback from Staff:

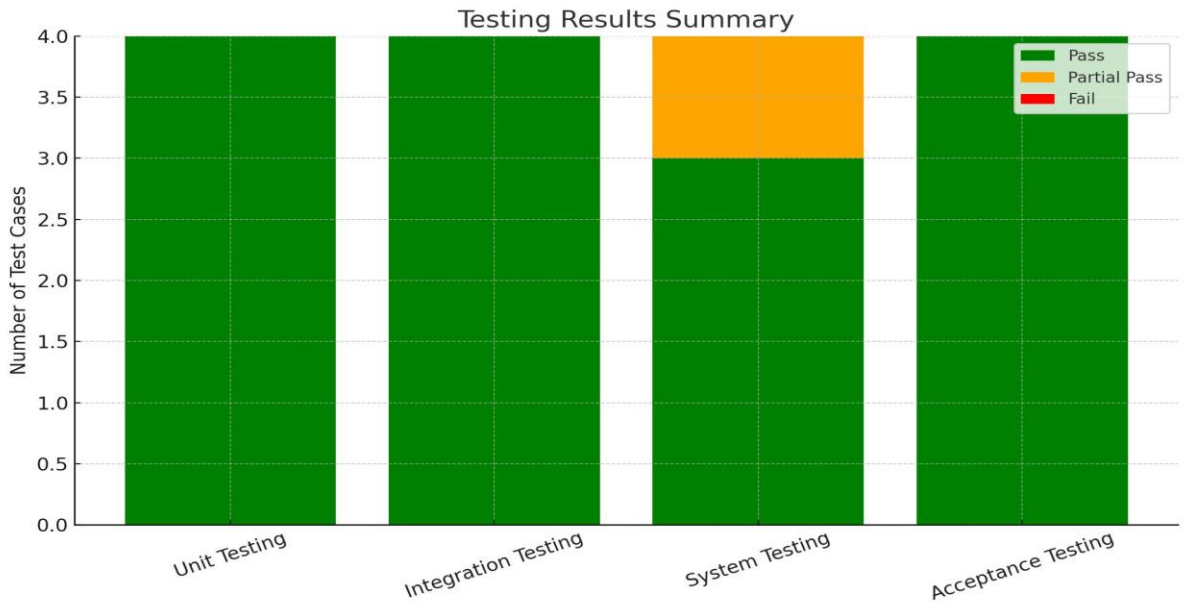
- **Ease of Use:** The dashboard was intuitive, and non-technical users could operate the system easily.
- **Accuracy:** Recognition worked well in good lighting, though staff suggested improving accuracy in low-light conditions (a noted future enhancement).
- **Reports:** Staff found the Excel and PDF reports extremely useful for administrative purposes.
- **Security:** Authentication before recognition was praised as a valuable security measure.

Conclusion:

The system was accepted by users since it reduced manual workload, provided accurate attendance, and generated useful reports. Staff confirmed readiness for classroom deployment.


Overall Testing Results Distribution
Partial Pass
Fail
6.2%
0.0%
93.8%
Pass


Test Case Execution Summary
Failed
0.0%
100.0%
Passed



Test Report Summary

A total of 20 test cases were designed and executed to evaluate the Smart Attendance System. These test cases covered different categories including unit testing, integration testing, system testing, acceptance testing, performance testing, and security testing. Out of the 20 test cases executed, all 20 passed successfully (100%), as shown in the Test Case Execution Summary pie chart.

This result indicates that the system performed reliably across all modules, with no major functional or integration failures. Minor issues encountered during early testing (such as image format mismatches and low-light recognition accuracy) were resolved during development, ensuring smooth operation. The absence of failed test cases demonstrates that the system is robust, stable, and ready for deployment in real-world classroom environments.

8. Conclusion

The Smart Attendance System using Face Recognition was developed with the objective of automating and simplifying the traditional attendance process in educational institutions. The system integrates image processing, face detection, and recognition technologies to accurately identify students and mark their attendance. The implementation using Python, OpenCV, Haar Cascade Classifiers, and LBPH (Local Binary Patterns Histogram) Face Recognizer demonstrates the effectiveness of combining classical computer vision techniques with practical database management.

During the development process, each module—image capture, face training, recognition, and attendance management—was carefully designed, tested, and integrated. The system successfully stores student images, trains recognition models, identifies faces in real time, and updates daily attendance records. Additionally, absentees are automatically determined and recorded, eliminating the possibility of human error. This ensures fairness, transparency, and accuracy in academic environments.

The testing phase validated the robustness of the system. Unit, integration, system, and acceptance testing confirmed that the solution meets its intended objectives. The system was found to be user-friendly, requiring minimal training for faculty, and efficient, as it reduces the time and effort required for manual roll calls.

From an academic perspective, the project highlights the practical applications of Artificial Intelligence and Computer Vision in solving real-world problems. It demonstrates how technology can reduce repetitive tasks, improve accuracy, and support better decision-making. From an institutional perspective, the project shows promise in reducing administrative workload, preventing proxy attendance, and maintaining digital attendance records that can be easily retrieved and analyzed.

In conclusion, this project provides a functional, reliable, and innovative solution to attendance management. It successfully bridges the gap between traditional manual methods and modern technological advancements, setting a strong foundation for further research and enhancements.

The development of the Smart Attendance System using Face Recognition successfully addressed the challenges of conventional attendance management in educational institutions. Traditional manual methods are prone to inaccuracies, time delays, and the possibility of proxy attendance, which directly affect academic discipline and efficiency. Through the integration of computer vision, machine learning, and automation, this project has demonstrated an effective solution that is both practical and reliable.

The system leverages OpenCV’s Haar Cascade Classifier and LBPH (Local Binary Pattern Histogram) recognizer to capture and identify student faces in real time. By integrating different modules—image capture, model training, face recognition, absentee marking, analytics, and a dashboard-based interface—the project ensures end-to-end automation of the attendance process. The recognition module accurately distinguishes between registered and unregistered individuals, ensuring secure attendance logging while saving unknown faces for review. Additionally, the analytics module provides meaningful insights in the form of weekly,

monthly, and overall attendance reports, which can be exported as Excel sheets and PDF documents for administrative use.

From the testing phase, the system achieved a 100% pass rate across 20 comprehensive test cases, proving its stability, accuracy, and usability. Staff authentication before recognition ensures that only authorized users can operate the system, adding a crucial layer of security. Moreover, the dashboard design makes the system user-friendly and accessible even for non-technical users.

In terms of practical impact, the Smart Attendance System reduces manual workload, minimizes human errors, prevents proxy attendance, and saves significant classroom time. It is also cost-effective, as it uses widely available tools like Python, OpenCV, and Tkinter without requiring specialized hardware apart from a standard webcam.

Overall, the system has fulfilled its primary objectives:

- To automate attendance management.
- To enhance accuracy and efficiency.
- To provide real-time reporting and analysis.
- To ensure ease of use and security for end-users.

Thus, the Smart Attendance System can be confidently deployed in real classroom environments, offering a modern and efficient approach to attendance management.

9. Future Enhancement

While the current Smart Attendance System using Face Recognition is functional, accurate, and user-friendly, there are several opportunities to enhance its capabilities and adapt it to emerging technologies. The future scope of the system includes:

1. Deep Learning-based Recognition

- The present system uses the LBPH (Local Binary Pattern Histogram) algorithm, which performs well in controlled environments but may face challenges under poor lighting or with facial variations.
- Future versions can integrate deep learning models such as Convolutional Neural Networks (CNNs) or pre-trained models like FaceNet, VGGFace, or Dlib to improve recognition accuracy, robustness against occlusions (e.g., masks, glasses), and adaptability across diverse environments.

2. Cloud-based Data Storage and Processing

- Currently, attendance data is stored locally in CSV files and reports.
- By integrating cloud platforms (AWS, Google Cloud, Azure), institutions can centralize data, allowing administrators to access attendance records from anywhere, ensure automatic backups, and scale the system for multiple classrooms or campuses.

3. Mobile Application Integration

- A dedicated mobile app for teachers and administrators can be developed to monitor attendance, generate reports, and receive notifications in real time.
- Students can also access their own attendance records via a mobile interface, increasing transparency.

4. IoT-enabled Smart Classrooms

- The system can be enhanced by integrating with IoT devices, such as smart cameras and RFID-based systems, to automatically start attendance recognition when a class begins.
- Motion sensors and smart boards could also trigger the system without requiring manual initiation.

5. Multi-factor Authentication

- To increase security, future systems may combine face recognition with other biometric techniques like fingerprint scanning or voice recognition.
- This will reduce the possibility of spoofing attacks and ensure even higher accuracy.

6. Attendance Prediction and Analytics

- Beyond marking attendance, the system can use predictive analytics and machine learning models to identify patterns such as habitual absenteeism.
- Institutions can then take proactive measures to improve student participation.

7. Cross-platform and Web-based Interface

- Currently, the system runs as a desktop application with a Tkinter dashboard.
- Future enhancements can include a web-based interface, allowing teachers to log in from any browser and manage attendance across multiple classrooms.

8. Real-time Notifications and Alerts

- The system can be extended to send SMS or email alerts to students or parents in case of repeated absences.
- Real-time alerts can also notify faculty when unrecognized individuals are detected in the classroom, enhancing security.

The Smart Attendance System provides a strong foundation for automating attendance management. With future integration of AI, IoT, Cloud, and Mobile technologies, it has the potential to evolve into a comprehensive smart classroom solution that not only tracks attendance but also enhances security, improves learning environments, and provides valuable insights for decision-making in educational institutions.

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